

**Draft  
Specification  
for  
Radio Remote Control System  
For  
Three Phase Locomotive Freight Locomotives**

SPECIFICATION NO: CLW/C-D&D/ES/3/0540

**(Issued in-----)**


**ISSUED BY:**

**Centre for Design & Development**

**Chittaranjan Locomotive Works**


**PO: Chittaranjan, West Bengal**

**India – 713331**

Radio Remote Control System For WAG-9/WAG-9H Three Phase Locomotive			 CENTRE FOR DESIGN & DEVELOPMENT CHITTARANJAN LOCOMOTIVE WORKS WEST BENGAL, INDIA NO: CLW/C-D&D/ES/3/ 0540				
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## CHAPTER-I

### GENERAL

#### 1.0 OBJECT & SCOPE


**1.1** Distributed Power Wireless Control System (DPWCS) of locomotives is a method to increase the throughput (or line capacity) of a railway line with minimal incremental inputs. In DPWCS, more than one MU Consist are provided in a train, the Master Locomotive is provided with crew but Slave Locomotive(s) are operated based on commands from Master Locomotive through wireless communication. The rear MU consists shall be distributed at any point in the train for example, in middle, at rear etc. The throughput increases due to haulage of long trains under same signal path, without increasing the axle load and coupler forces. Efficiency increases due to relative reduction in input costs like crew, operating staff and associated logistics in moving the same GTKM.

This specification defines the Radio Remote Control System (RRCS) which shall be used to achieve the Distributed Power Wireless Control of locomotives.

**1.2** The scope of this specification is to develop, manufacture, test, supply, installation & commissioning of RRCS for WAG9/WAG9H class of three phase electric locomotives. The primary objectives of this system are


- (i) To enable full control of Remote Locomotive(s) placed in middle and/or rear of train based on the driver initiated actions in Lead Locomotive through wireless control. On successful development and trials, the requirement of drivers in Remote Locomotive(s) shall be reviewed.
- (ii) To have smoother train operation by reducing coupler forces.
- (iii) To have smaller braking distance and quick brake application/release for long haul freight trains

**1.3** Definitions and meaning of terms:


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For the purpose of this specification, the following definitions shall apply:

SN	Term	Meaning
1	Bidder	The Firm or company who submits the offer for supply of equipment as per this specification
2	Contractor	Any Firm or Company with whom the order for supply of the equipment as per this specification shall be placed or intended to be placed
3	Purchaser	Any unit of Indian Railway
4	RDSO	Research Designs and Standards Organization, Ministry of Railway, Manak Nagar, Lucknow – 226011
5	CLW	Chittaranjan Locomotive Works, Chittaranjan (WB) – 713 331
6	C-D&D	Center for Design and Development, CLW
7	Inspecting Officer	A person nominated by the Purchaser to inspect the equipment on his behalf or the representative of the Inspecting Officer so nominated
8	MU Consist	2 locomotives coupled together and connected through wired couplers. This is also referred in brief as 'consist'
9	Master Locomotive	A locomotive in the lead of a train, provided with a crew to operate.
10	Lead Locomotive	Locomotive attached at the head of the train. Lead locomotive in case of MU consist means the first front locomotive of the MU Consist.
11	Trail(ing) or Remote Locomotive	Locomotive placed at a location other than leading position in a train consist. In case of MU Consist, Trail or Remote locomotive is the first front loco of the MU Consist
13	Closed Coupled Operation	Lead and trail locos coupled together and operating together through wireless link.

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SN	Term	Meaning
		This is also referred in brief as 'Wireless consist'.
13	Synchronous Remote Control	Simultaneous repetition & execution of commands, given by lead locomotive to trail locomotive by a wireless link, such as traction, air braking, dynamic braking or any other function performed by the driver of the lead unit and duplicated (transmitted) in trailing units and simultaneous braking in Lead and in Trail locomotive(s) if braking command is initiated from any of the Trail Locomotives.
14	Electric Loco Shed (ELS)	Facility provided on the Indian Railways for upkeep of electric locomotives where periodic schedule maintenance as well as unscheduled maintenance of locomotives is carried out.
15	Block Section	A portion of running line where only one train is allowed to operate at a time on one track. The entry and exit from the block section is controlled by appropriate signals.
16	Neutral Section	A portion of overhead equipment (OHE) in electrified section which is dead i.e. neither charged nor earthed. Such section is provided between two portions of OHE, which are fed by different phase. There are different types of neutral section in Indian Railways, each type having different length. In all types of neutral sections, opening of 25 KV Circuit breaker of loco (called VCB hereinafter) is shall. For guidance of driver caution & reminder boards are placed at 500m and 250 m ahead of neutral section followed by 'VCB open' board at the location


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SN	Term	Meaning
		where VCB shall be opened. After negotiating neutral section, VCB shall be closed on 'VCB close' board
17	BP	Brake pipe
18	FP	Feed pipe
19	BC	Brake Cylinder
20	AFI	Air flow indicator
21	RRCS	Radio Remote Control System
22	E-70 Brake Control	A brake control system, which is proprietary to M/s.Faively, equipped in WAG9/WAG9H class locomotives.
23	CCB	Computer Controlled Brake system, which is proprietary to M/s.Knorr Bremse, equipped in WAG9/WAG9H class locomotives.
24	UHF	Ultra High Frequency
25	GPS	Global Positioning System
26	DPC	Distributed Power Control
27	WPC	Wireless Planning & Co-ordination Wing, Govt. of India
28	OEM	Original Equipment Manufacturer
29	GTKM	Gross Tonne Kilometer
30	ER	Equalising Reservoir
31	MVB	Multifunction Vehicle Bus
32	RF	Radio Frequency
33	TE/BE	Tractive Effort/Braking Effort

#### 1.4 CONTRACTOR'S RESPONSIBILITY:

The contractor's responsibility shall include following:

- 1.4.1** Commissioning of the equipment supplied. The Contractor shall depute his engineers/supervisors to CLW/ELS /workshop for installation of the equipment on locomotive. However, cabling shall be done by the Purchaser as per advice of Contactor.
- 1.4.2** Supply of detailed commissioning instructions for proper installation of the

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equipment on the locomotives. Installation instruction shall be provided in acceptable form e.g. Instruction card. These instructions shall include the method of inter connection, type of cable and grade of cable, maximum resistance and whether the cable required is screened or otherwise. The Contractor shall provide specification of screened cable and prospective sources for the purpose of maintenance. Details of any special precaution necessary shall also be stated.

**1.4.3** Provide required instrumentation and carry out detailed tests and field trials jointly with RDSO/CLW/Railways.


**1.4.4** Provide special tools, instruments and test bench etc along with documentation, which shall be required for maintenance.

**1.4.5** Training: The Contractor shall arrange for free of cost training of Indian Railway personnel in installation & commissioning, operation, maintenance and trouble shooting of the system supplied. Contractor shall also provide detailed technical write-up to all the trainees. The syllabus for training shall have to be approved by the purchaser. The venue of training shall be at the place of commissioning of the system and at the destination shed.

**1.4.6** User's manual: The Contractor shall supply sufficient copies of User's manual in hard copy as well as soft copy. This shall include system description and operating, maintenance, calibration and troubleshooting instructions up to component level. List of spares with part number/technical specification shall also be included. Number of copies to be supplied shall be 10% of the number of equipment ordered, subject to a minimum of 5 copies per order.

**1.4.7 APPROVAL FOR DESIGN**

**1.4.7.1** The design shall be developed based on the requirements given in this specification by using latest technology and sound engineering practices. During design approval stage, the contractor shall submit design document, drawings, BoM, etc, to RDSO and CLW for examination and approval. However, contractor shall be bound to furnish

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any other design detail as shall be required by RDSO and CLW for evaluation of the offered system


- (i) Block diagram functional description of the system offered. Description shall necessarily contain explanation as to how each of functional requirements of this specification is met with.
- (ii) Design details of the hardware indicating make, technical data/ratings and governing specifications.
- (iii) Flow chart description of the logic used in the software.
- (iv) Coloured sectional view diagrams of the pneumatic/Electro-Pneumatic valves used along with explanation of their operating principles.
- (v) Mechanical drawings of complete system and its subsystems/subassemblies with details of dimensions, mounting arrangement and weight shall be provided.
- (vi) Bill of Material (BOM) clearly indicating bought out items and in-house manufactured items. Make and International governing specification of the bought out items shall be furnished.
- (vii) Other requirements as specified in forthcoming chapters.

**1.4.7.2** The Contractor shall not commence manufacture before clearance of the design by RDSO.

**1.4.7.3** Approval of design means the approval of general design features. Notwithstanding the approval, the Contractor shall be wholly responsible for the performance of the system.

**1.4.8 FIELD TRIALS:**

After clearance of design & successful completion of type tests, the prototype equipments shall be subjected to field service trials for a minimum period of six months. The number of trial equipments and

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venue shall be as agreed between the purchaser and the Contractor. The installation and commissioning of the equipments for field trials shall be carried out by the Contractor. The supply and commissioning of the balance equipment against the order shall start only after successful trial and incorporating improvements measures arisen out of trial for successful performance of the equipment in the field. Consumable materials, electrical energy for testing and commissioning of the RRCS shall be provided by the Purchaser free of cost.


#### 1.4.9 INFRINGEMENT OF PATENT RIGHTS:

Indian Railways shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, use of components, used in design, development and manufacturing of RRCS and any other factors which shall cause such dispute. The responsibility to settle any issue lies with the Contractor.

#### 1.4.10 DOCUMENTATION:

The Bidder shall submit the following information with his offer in printed form and neatly compiled in a booklet form. Offer with incomplete information shall not be considered.

- a) Clause by clause comments on this specification.
- b) Statement of deviations to clauses of this specification indicating the reason thereof.
- c) Brief block diagram functional description of the system.
- d) Broad mounting dimensional drawings of the system and its subsystems/subassemblies indicating weight of each assembly.
- e) Brief design details of each sub-assembly including broad ratings/specifications.


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- f) Make and International governing specification of the bought out subsystems/sub-assemblies.
- g) MOU (Memorandum of understanding) with the collaborator, wherever applicable.
- h) QAM (Quality assurance manual)
- i) ISO 9001 certification.
- j) Details of infrastructure, manufacturing and testing activities

1.5 RAILWAYS' RESPONSIBILITY:

Railway shall be responsible for followings:

- 1.5.1 Labour, consumables and electrical energy required for erection, testing & commissioning of System.
- 1.5.2 The wages and allowances as well as the cost of the travel to and from the place of training for railway personnel.

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## CHAPTER II

### TECHNICAL DETAILS

#### 2.0 SYSTEM REQUIREMENTS.


The system shall have testability built in the design to ensure the reliability and safety level required to run the loco with such electronic/telecommunication equipment. Each Unit of the RRCS shall comprise two Driver Interface Units (DIU) one in each cab, Control & Communication Unit (CCU) and Brake Interface Unit (BIU) or as per requirement along with other necessary interfacing devices and interconnecting cables. One set of RRCS equipment shall comprise equipment for two locomotive. The RRCS equipments in each locomotive shall be exactly similar.

#### 2.1 DRIVER INTERFACE UNIT (DIU)

2.1.1 DIU shall function as an interface between the driver and system. It shall have necessary keys for this purpose and the interface shall be user friendly. DIU shall be provided in each cab at appropriate location for convenience of driver after approval of RDSO. The DIU shall act as a dumb terminal simply to receive and display information from CCU and to send keyed in information to CCU. The DIU shall run from 110 V dc power available in the loco. DIU shall be back-lit LCD type to achieve good readability and it shall have adjustable contrast and backlit control for all time visibility. The menu items, input keys/buttons and interface features and layout etc shall be provided to meet the functional requirements and shall be got approved from RDSO before manufacture.


2.1.2 Each Driver Interface unit shall be connected with CCU by means of military grade bayonet type circular coupler for communication with CCU from both the cabs. A 3 pin same type of coupler shall be used for power supply. The data on display shall be updated at least once every 500 msec.

2.1.3 The DIU shall be designed to provide following provisions/functionality for display of information, providing alerts and

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alarms.

- (i) Default screen of DIU shall continuously provide display of critical parameters and status of leading as well as remote locos which shall essentially include following:
- Healthiness of communication link
  - BP, FP, BC, MR pressure and AFI
  - Status of VCB
  - Traction status
- (ii) Default screen shall automatically resume after an idling time of max 10 seconds of display of some other screen if the driver had selected same for viewing/performing some action. A key/button shall also be provided on DIU for selecting the default screen at once.
- (iii) An audio visual alert system shall exist on DIU for various abnormal situations for guidance of driver. The audio alert shall be in form of buzzer and visual alert shall be in form of contextual text display on screen. Provision for acknowledgement of audio visual alert by driver, wherever necessary, shall be provided. After acknowledgement of alert, audio buzzer shall stop sounding. The type of alerts and their contextual text shall be got approved from RDSO before commencing manufacture. However, situations where alert is required shall essentially include following.
- Communication loss/interruption
  - Remote loco(s) BP charging valve cut-out
  - Train parting
  - Wheel slip

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- (iv) The DIU shall be ergonomically designed to provide easy access and user friendly interface to driver. The location of various switches/keys/buttons, number of information display screens, layout of each screen, contextual text for various alerts/alarms etc shall be got approved from RDSO before commencing manufacture.
- (v) Each loco has a diagnostic terminal (also called PIXY) to display loco parameters for operation purpose. In case of RRCS, the display of each slave loco shall be enunciated on Master Locomotive's DIU.
- (vi) CLW has developed a Driver Display Unit (DDU) as per Specification No. CLW/ES/3/0487 Alt. B (or latest). In this DDU, 10.4" color display is used to show the different parameter/signals of the locomotive. The Contractor can use the same DDU to receive and display information from CCU and to send keyed in information to CCU. This way there shall be only one display in each Driver's Cab which shall show all the functionality description in DIU & DDU. In such case the DDU with all the functionalities shall be in the scope of supply.

2.2 CONTROL & COMMUNICATION UNIT (CCU):

2.2.1 Control & Communication Unit (CCU) shall comprise of power supply module, microprocessor module, hardware module, software module, memory module and data transmission/reception/decoding modules.

2.2.2 Considering the safety involved with the heavy haul operation of rolling stock in DPC, the CCUs shall have high degree of reliability and redundancy. The redundancy among different control units, processor cards, power supply units, Radio Transceiver, etc, shall be a matter of design which shall be finalized during the design stage.

2.2.3 CCU shall be interfaced with MVB to pick up electrical control commands and shall convert the same in RF signals and transmit to Trail Locomotive(s). While in Trailing Locomotive, same unit shall be able to receive RF signal and pass into the MVB of the other locomotive for

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execution of commands. If the Contractor proposes to have different topology than the interface through the MVB the same need to be submitted in detail to RDSO for approval.

2.2.4 CCU shall have sufficient non-volatile storage capacity for storing log of important events, fault conditions and status of data transmission/reception. CCU shall also be provided with standard communication ports like RS-232, RS-485, Ethernet port and USB port to facilitate data exchange from external devices. Necessary commands for such data exchange shall be provided on DIU. The nature of events to be logged and their format shall be got approved from RDSO. The software to analyze the data log shall be in scope of supply of RRCS.


2.2.5 Communication Module shall contain radio transceiver. The radios shall have the feature of programmable RF output and frequency. There shall be feature to see the RF output either on the Radio itself or through some suitable interface. The RF output shall also be displayed on the DIU.

2.2.6 Considering the dynamic nature of network, where the RF system is expected to perform with robustness while the locomotive is in movement and the environment changes continuously with time, built in space diversity on the radio equipment level where the signal is compared for the quality and strength on the RF level shall be available.

2.3 BRAKE INTERFACE UNIT (BIU):

2.3.1 The system shall include a Brake Interface Unit which shall interface to the existing E-70/CCB brake system of loco to provide full control of the Automatic (Train) brakes, the Independent (Loco) brakes and emergency brakes.

2.3.2 Considering the safety involved with the heavy haul operation of rolling stock in DPC, the BIUs shall have high degree of reliability and redundancy. The redundancy among different control units, processor cards, power supply units, etc, shall be a matter of design which shall be

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finalized during the design stage.

- 2.3.3 The actions of driver in Lead Locomotive with respect to application/release of brake shall be duplicated in Remote Locomotive(s) through this interface unit. Contractor shall have to study the existing brake system of locomotives for this purpose. The Purchaser shall provide manuals of locos to Contractor for this purpose.
- 2.3.4 The BIU shall be such that the existing functionalities/features of E-70/CCB Brake system provided on loco remains intact.
- 2.3.5 The BIU shall comprise of pneumatic/electro-pneumatic valves, pressure sensors/transducers, air flow measuring device, gauges, etc for interfacing with loco BP/FP/BC/ER/MR pressure pipeline. Provision and installation of such equipments along with piping etc shall also be in scope of supply. The pneumatic/electro-pneumatic valves, pressure transducers, air flow measuring devices, gauges, etc used in BIU shall be of proven design for rolling stock applications.
- 2.3.6 The Contractor shall take the approval of BIU arrangement from OEM of brake system (E-70/CCB) before furnishing the details to RDSO.
- 2.3.7 The Contractor shall furnish complete design detail of the proposed BIU arrangement to RDSO for examination and approval before commencing manufacture.


2.4 Operating Modes:

It shall be possible from lead loco to place remote Loco(s) in the following operating modes: Necessary mode selection buttons/switches/keys shall be provided on DIU for this purpose.

- (i) ISOLATE: In this mode system remains powered ON but wireless control functions are totally disabled.
- (ii) IDLE: In this mode electrical functions of the Lead Locomotive are not performed on the remote locos but air brake functions are performed.
- (iii) BRAKE: In this mode only electrical brake and air brake functions of the Lead Locomotive are performed on Remote Locomotive(s).

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- (iv) SYNCHRONOUS REMOTE CONTROL: In this mode all electrical and air brake functions of the Lead Locomotive are performed on Remote Locomotive(s).
- (v) INDEPENDENT CONTROL: In this mode the electrical power and electrical braking functions of the Remote Locomotives shall be independently controlled via the DIU of Lead Locomotive.
- (vi) BRAKE VALVE OUT: In this mode, the brake valve shall be cutout and automatic brake functions of Lead Locomotive shall not be duplicated in Remote Locomotive(s).


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## CHAPTER III

### 3.0 FUNCTIONAL REQUIREMENTS


- 3.1 The system shall be suitable to work within UHF frequency band. Moreover, the system shall be capable of simultaneously handling at least 6 trains equipped with the RRCS in a radius of 3 kms efficiently and without loss of communication on a single UHF channel of 25 KHz. Each such train shall have up to 4 Remote Locomotives.
- 3.2 Indian Railway shall obtain the allocation & operating license thereof for adequate number of UHF channels or sufficient spectrum from Wireless Planning and Coordination (WPC) wing of Ministry of communication & IT, Government of India for the use of RRCS system on IR. However, there is possibility that the frequency of channels so allocated is different in different geographical area. Therefore the System shall have the capability of automatically switching to the available frequency channel.
- 3.3 In future, Indian Railway shall prefer to operate the RRCS on GSM-R communication link. Therefore, the system shall be designed in a modular fashion for its easy upgradability to GSM-R in future. Brief details of the module to be changed/modified for such up-gradation shall be indicated by Contractor in their design document.
- 3.4 Performance of the system shall not be affected by other RF devices in vicinity and at the same time the system shall also not affect the working of other RF devices in the vicinity. Contractor shall mention, and give a copy thereof to RDSO, the international/national standards through which this requirement is proposed to be tested. However, RDSO after examining these standards shall ask for testing through some other standards considered appropriate. It shall be the responsibility of Contractor to arrange such testing at his own cost. Contractor shall not commence manufacture until the testing protocol is approved by RDSO.
- 3.5 The system shall provide control of Remote Locomotives (up to 4 locomotives) of the train by signals transmitted over a (through) wireless link from Lead Locomotive, up to a distance of 1500 meters from Lead Locomotive. The system shall be capable of operating in continuous tunnels, forest area and deep cuttings without any loss of contact over wireless link.

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However, in critical locations where continuity of communication cannot be ensured due to high curvatures/physical obstruction in line of sight in tunnels, system shall have necessary provisions to ensure continuous communication through radiating antenna/external repeaters/leaky cables to be provided at such locations. The Contractor shall assist IR in identifying such critical locations during initial trial runs and shall provide details of the radiating antenna/external repeaters/leaky cables along with procurement specification & sources for installations at such locations. However, supply and installations of such radiating antenna/external repeaters/leaky cables shall not be in the scope of RRCS.


- 3.6 Performance of the system shall not be affected by the overhead traction of 25 KV AC and high voltage transmission lines in the vicinity of track.
- 3.7 System shall be fool-proof so that it is not affected by similar units in other trains passing on the adjacent electrified/non-electrified track or operating in a vacant Block Sections or a terminal or a cutting. The performance of the system shall also not be affected by three phase locomotive/EMUs, fitted with GTOs/IGBT control, which shall be working on nearby track.
- 3.8 System shall not cause interference to colour light signaling equipment or any other signaling installation provided on the Indian Railways.
- 3.9 The RRCS equipments for Lead Locomotive and Remote Locomotive(s) shall be identical so that any locomotive fitted with this system shall be utilized as Lead or Remote locomotive in a train.
- 3.10 The existing wire couplers of the locos shall be retained and their functionality for forming multiple units shall be retained and unaffected by the system.
- 3.11 During initial set up of train, RRCS shall allow pairing of locomotives of same train only. For this purpose, continuity of BP pressure shall be taken as one of the verification item besides the identity of the locomotives. The system shall have an inbuilt feature of checking continuity of the BP pressure. The algorithms proposed to be used for checking continuity of BP pressure shall be got approved from RDSO before commencing manufacture.

At start of pairing process the system shall ask inputs from driver .These input shall include Driver ID, train name, loco numbers with their position


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(Lead,Remote-1,Remote-2 etc), no of wagons/coaches in train. The system shall only communicate with paired Trailing Locomotives of the train.

- 3.12 The RRCS shall be capable of full control of Remote Locomotives while working in Closed Coupled Operation as well as in Remote Control Operation. However, while working in Closed Couple Operation, air brake functions of Remote Locomotives through wireless control are not required. In case of two/three RRCS fitted locomotives are in MU as Lead/Trail Locomotives & are coupled through twisted wire coupler and for any reason if the twisted wire coupler is defective; provision of switchover to wireless control of locomotives in MU consist shall be possible and the locomotives in the consist shall be treated as a group i.e. lead/trail and shall follow the traction/braking commands of Lead locomotive in same manner as coupled with twisted pair wire coupler.
- 3.13 The RRCS shall be safeguarded against possibility of taking over control of the Lead as well as Remote locos by any unauthorized person using wireless means. The Contractor shall explain in their design document as to how this requirement is met with.
- 3.14 The algorithm for control & indications to be used in the RRCS shall be deduced by the Contractor after studying the existing electrical control arrangement and braking system of WAG-9 class of three phase electric locomotive. For this purpose, the Purchaser shall provide manuals of these locos to Contractor. The algorithm of the system shall be finalized after RDSO approval. The details of various nodes and the conditions to be fulfilled for arriving that state (node) is given as Annexure- I bearing document no. as 3EHP 541871 rev. B 00-04-04/WA for ready reference for verifying the algorithm/interface.
- 3.15 It shall be possible to shut down (VCB open and pantograph lower) Trailing Locomotive(s) at any time from Leading Locomotive. Suitable user friendly interface shall be provided on DIU for this purpose. Similarly it shall also be possible to energize and bring to traction the paired Trailing Locomotive(s) at any time with the help of simple user friendly interface at DIU. While shutting down the Trailing Locomotive(s), the TE/BE shall gradually come to zero before opening of VCB. Similarly, while energizing the trailing Locomotive(s), TE/BE shall progress gradually to the position corresponding to leading Locomotive.


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- 3.16 In normal operation, the RRCS shall execute the same action as are being done by driver in Leading Locomotive, i.e., TE/BE command through master controller, shunting mode, operation of reverser, traction/braking mode through master controller, etc.
- 3.17 In case of traction/braking interlock in the Lead Locomotive, TE/BE in Trail Locomotive(s) shall also be prohibited.
- 3.18 In case of processor card (STB, HBB & FLG) failure of Trail Locomotive; it shall be possible to control the train from inactive cab of Trail Locomotive whose processor cards are healthy.
- 3.19 In case of intermittent faults in Trail Locomotive(s), it shall be possible to switch off and switch on the electronics of Trail Locomotive(s) from Lead Locomotive.
- 3.20 Negotiation of Neutral Section: There are Neutral Sections on OHE roughly at every 30 to 40 km. There is caution board at 500 m ahead of Neutral Section to caution the driver of approaching Neutral Section, followed by reminder board at 250 m ahead of Neutral Section and then VCB opening board where driver shall open the VCB. These boards are placed on fixed structures (normally OHE masts) alongside the track. After negotiating Neutral Section, driver closes the VCB at VCB closing board. In case the VCB remains closed in Neutral Section, it shall lead to unsafe condition and therefore it is shall that VCB is in open condition while negotiating Neutral Section. The RRCS shall be able to meet this requirement for remote locos (or consist). The manner of handling Neutral Section and other requirements are as follows:
  - (a) While approaching Neutral Section, driver opens the VCB of lead loco at 'VCB open' board, closes VCB at 'VCB close' board and then start taking TE in Lead Locomotive while during this period ( period during which Lead Locomotive VCB remains open) Trailing Locomotive(s) remain energized and on traction pushing the train. After negotiation of Neutral Section by Lead locomotive, when Trailing Locomotive arrives at 500 m board, its TE starts reducing and becomes zero on reaching 250 m board followed by opening and closing of VCB at 'VCB

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open' and 'VCB close' board respectively. Contractor shall have to build additional software logic to achieve this functionality.

- (b) System shall include a GPS device which shall be used for handling negotiation of Neutral Section. Neutral Section button shall be provided on the DIU for the purpose of negotiating the Neutral Section. While approaching Neutral Section, Lead Locomotive driver shall press NS button on DIU thereby indicating that now system has to handle negotiation of Neutral Section in Remote Locomotive(s). After pressing NS button, when driver opens VCB, the system shall lock the GPS coordinates and Remote Locomotive(s) shall start monitor their GPS position and system shall cause reduction of TE/BE then opening of VCB when Remote Locomotive(s) reaches to locked GPS coordinate position. The accuracy of GPS shall be taken into account for achieving safe negotiation of Neutral Section. To cater to the situations of poor GPS signal availability, system shall have a backup provision based on speed monitoring and length of train to handle negotiation of Neutral Section. Suitable algorithm for calculation of train length deduced from number of wagons/coaches entered by driver and speed/time measurement etc shall have to be devised in the RRCS. The effect of curvatures and slacks in couplings between wagons/coaches shall also be taken care of in algorithm as these factors shall affect train length. System shall take input for speed from speedometer or from MVB. In case the speed monitoring is done by speedometer then arrangement shall be such that if failure of speedometer of Leading Locomotive, speed input is taken from speedometer of Trailing Locomotive(s).
- (c) There shall be at least two different ways of identification of the location of the Neutral Section as mentioned in clause (b) above and the Neutral Section shall be negotiated based on more accurate of the two.
- (d) While approaching Neutral Section, VCB of concerned loco shall open on or before (max 15 meters) 'VCB open' board. Similarly after negotiating Neutral Section, VCB of concerned loco shall close only on or after (max 15 meters) 'VCB close' board.
- (e) In case if any locomotive is stuck up in Neutral Section for any reason, it shall be possible to provide traction from other locomotive(s) to clear the Neutral Section. Suitable interface shall be provided on DIU for this purpose.

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- (f) The system shall be fail-safe so that no violation of above conditions of negotiating Neutral Section takes place. The Contractor shall study the system of speed measurement in loco and type of couplings used & their slack etc before framing algorithm so that above requirements are complied with stated accuracies.
- (g) The system shall be able to negotiate Neutral Section in case of communication failure between Lead & Trail Locomotive(s) during negotiation of Neutral Section.

3.19 Sometimes there are restrictions for lowering of pantograph between specified locations. This requirement shall have to be handled with the same logic as for negotiating Neutral Section elaborated in preceding clause with an additional function of lowering/raising of pantograph. System shall be able to lower the pantograph of trailing locos (or consists) in such restriction at specified locations with same accuracies as mentioned in previous clause.

3.20 System shall be able to identify train parting and in such cases Remote Locomotives, if any, in parted rear portion of train shall come to idle position. If in case of train parting, driver of lead loco applies emergency brake, this emergency condition shall be sensed by remote locos where similar brake application shall automatically take place to avoid collision of separated portions of the train. Moreover, whenever the BP pressure in trailing locos goes below 4.5 Kg per cm<sup>2</sup> the affected Remote Locomotive shall come to idle position.


3.21 System shall continuously check for the healthiness of the communication link between Lead and Remote Locomotive(s). Check shall be initiated by Lead as well as Remote Locomotive(s) so that RRCS of each locomotive (Lead or Remote) has the real time information of health of communication link.

3.22 Whenever there is communication failure between Lead Locomotive and Remote Locomotive(s) for whatsoever reason, the affected Remote Locomotive(s) shall remain in last commanded state and a specified period timer shall start. If communication resumes within this specified period,

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system shall perform self test, ensure identity of Remote Locomotive(s) and then bring the affected Remote Locomotive(s) in synchronism with Lead Locomotive. If communication is not resumed within specified time period, the affected Remote Locomotive(s) shall come to idle position (zero traction position).The system shall have the facility of adjusting the timer period so that same shall be optimized during initial trials. Moreover, if the Lead Locomotive driver makes a train brake application during communication loss period, this condition shall be sensed by RRCS of remote locos and system shall bring the Remote Locomotive(s) to idle position. Alert to driver for communication failure shall be provided on DIU.

- 3.23 In the event of failure of Leading Locomotive for whatsoever reason, system shall provide the functionality to driver of Leading Locomotive to work the train from Trailing Locomotive(s) at a restricted speed and a suitable user friendly interface shall be provided in DIU for this purpose.
- 3.24 System shall log the events of communication failures/other failures in memory and at any point of time data of last 100 days shall be available. System shall also continuously log the commands transmitted/ received/ decoded by system and at any point of time data of last 3 days shall be available in memory. It shall be possible to download this data through communication ports provided on CCU. Suitable downloading commands shall be provided on DIU or CCU for downloading of data. Extent and format of data elements for logging and storage of such data shall be got approved by RDSO before manufacture. Any special software to read and anylise the downloaded data shall also be within the scope of supply.
- 3.25 Self Test: The system shall run a self-test at power ON and continuously in real time to verify the satisfactory functioning of all system/sub-systems including I/O. During this operation, the system shall be capable of identifying internal faults as shall occur from time to time and their indication to the driver. Fault recovery capabilities and limited fault tolerance are desirable features, which shall be indicated in the offer for evaluation of the system.
- 3.26 Pneumatic Braking: The system shall meet the following functional requirement in respect of pneumatic braking:
  - (i) Train braking shall be controlled from both the Lead as well as the Remote Locomotive(s). The actions of driver in Lead Locomotive with respect to application/release of train brakes, independent brakes &

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emergency brakes shall be duplicated in Remote Locomotive(s) through wireless commands from Lead Locomotive and BIU. The status of BP/BC/FP/MR pressure and air flow in Remote Locomotive(s) shall be displayed on DIU of Lead Locomotive.

- (ii) During communication interruptions, if the Lead Locomotive driver makes train brake application, the system shall seal the BP (i.e. BP charging/destruction not possible from affected remote loco) from BIU of affected remote loco. In such communication failures, train brakes shall only be controlled from lead loco. Suitable alert to driver shall be provided for such situations.
- (iii) If BP charging continues despite condition in (ii) above in affected Remote Locomotive(s) (this shall happen due to command not getting executed properly or due to some fault in brake valve) during communication interruption and the lead loco driver makes a brake application, this situation shall be sensed by affected Remote Locomotive by measuring air flow into the BP & BP pressure. BIU shall have the capability to stop BP charging in such situations. For this purpose BIU shall have arrangement to continuously monitor the air flow into the BP.
- (iv) The emergency brakes shall be applied on all locomotives in RRCS if braking command from assistant loco pilot emergency brake is actuated from any of the locomotive in the RRCS.
- (v) The emergency brake application due to fault in electronics in any of the locomotives in RRCS shall cause emergency brake application in all locomotives in the RRCS. Similarly; if penalty brake application takes place by VCD in Leading Locomotive then the simultaneous emergency brake application shall take place in Trail Locomotive(s) also.
- (vi) There shall be provision feedback in form of audio- visual (the audio alert shall be in form of buzzer and visual alert shall be in form of contextual text) on DMI of Lead Locomotive for failure of brake interface of Trail Locomotive and of Lead Locomotive.

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(vii) There shall be provision of isolating the CCU and BIU of Trail Locomotive(s) from Lead Locomotive in case of any fault in CCU and BIU.

(viii) There shall be provision of isolating Independent locomotive brake of Trail Locomotive(s) by using suitable electro pneumatic valve.


3.27 Wheel Slip: Provision of automatic sanding in case of wheel slip on remote unit without any action by the driver on the lead unit shall be made. When automatic sanding is taking place on the Remote Locomotive(s), indication shall come on the Lead Locomotive.

3.28 Sanding: In case, sanding switch is operated from the Lead Locomotive, system shall cause operation of sanding gear on the Remote Locomotive(s) automatically with its indication being displayed on Lead Locomotive.


3.29 The RRCS shall also log the events of brake application (train brake, loco brake, emergency brake) by driver along with the values of BP and BC pressure. The logging shall be done in memory of RRCS in lead as well as remote locos. The system shall log these events in all operating modes except when switched off.

3.30 Inter-operability: The system shall be designed to have inter-operability across RRCS of different make to achieve flexibility in operations. The aspects of the inter-operability along with the common communication protocol shall be worked out and finalized during the design stage. .

3.31 In some locos Train Protection & Warning System (TPWS) or Anti Collision Device (ACD) shall be fitted. TPWS is an ERTCS level-1 system which monitors the working of driver with respect to observance of Maximum Permissible Speed (MPS) and signal aspects and applies service or emergency brakes in case of defaulting conditions. ACD is a GPS based system which applies service or emergency brake to avoid collision like situations. As crew shall not be available in Remote Locomotive(s), RRCS shall take care of operation of these systems in Remote Locomotive(s) by suitable system design.

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3.32 Based on the experience/system information gained during product design/development/testing/trial etc, above functional requirements shall be reviewed and/or additional functional requirements shall be stipulated, which shall be necessary for safe and efficient operation of trains. The contractor shall be bound to modify the design within **warranty** period to satisfy such requirements.

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## Chapter-IV

## 4.0 DESIGN REQUIREMENTS

- 4.1 The design of the system shall be robust and of state-of-the-art technology. The design shall be modular up to card level for ease of maintenance and fault troubleshooting. As far as possible Contractor shall design the system by using standard cards/devices which are freely available in market.
- 4.2 System shall draw power from loco battery. The battery supply voltage is 110V DC which shall vary from 70V to 136V and is supported by the existing battery charging arrangement available in the locomotive. The system shall be designed to work with this supply without any problem. Since memory storage are to be catered for, a battery backup as a part of the system shall also be provided.
- 4.3 Power supply system of RRCS shall have two power supply cards, one shall be working normally and other shall be hot standby. In case of failure of one card, switchover to healthy card shall be automatic with an indication on DIU and corresponding log in the memory of failure of first card.
- 4.4 It shall be preferable to have the entire hardware, CPU, RAM, EPROM, Input/output ports and opto-isolation etc. so optimized that the component count is kept low without sacrificing the overall system performance and reliability. As far as possible hardware shall be plug-in type. Necessary interfacing hardware and the connectors shall be provided on the cabinet of the equipment.
- 4.5 All the cards shall be suitably protected, enclosed and provided with mechanical dust proofing covers to avoid dust ingress and then mounted in a robust metallic housing so that entire assembly is capable of withstanding shocks, vibrations, electromagnetic induction and electrical surges etc. Electromagnetic compatibility of the entire system shall comply with provisions of IEC-60571 and IEC-61000. The equipment shall withstand surge & spikes as specified in IEC-60571.

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- 4.6 RRCS unit fitted on either lead or trailing locomotive shall be interchangeable. In order to have common Inventory of radios used in transmission/reception module, the radio modems shall have minimum 2.5 MHz Bandwidth which shall be programmed as per WPC allocation at site instead of changing hardware.
- 4.7 Adequate provisions shall be made in the design for suppression of internal transients, spikes and to withstand external transients, spikes and surges as per limits laid down in IEC-60571.
- 4.8 In the electronic/telecommunication equipments to be supplied to this specification, the Bidders shall use components and systems of high reliability, suitable in every way for the application on rolling stock. In this connection, Bidder is well advised to refer to "Rules for Electronic Equipments used on Rail Vehicles IEC Publication 60571".
- 4.9 Minor deviations from the specification if any, shall be mutually sorted out with RDSO during development stage if supported by justification on ground of cost and/or technical superiority.
- 4.10 All the components on PCBs shall be wave soldered/surface mounted devices shall be mounted using SMT workstation and complied with clause no. 7 of RDSO specification no. ELRS/SPEC/ SI/0015.
- 4.11 All ICs if mounted on the bases shall be mounted on heavy duty sockets and provision shall be made for tightening of the ICs on the base also complied with clause no. 6.1.3 of RDSO specification no. ELRS/SPEC/ SI/0015.
- 4.12 All electronic components and ICs used shall be selected after proper burn-in and screening tests and shall be adequately rated to withstand the service requirements. A quality assurance scheme shall be submitted by the Contractor for approval of RDSO. It shall be provided as per specification no. ELRS/SPEC/ SI/0015.
- 4.13 Polarized bayonet type circular connector shall be used for all external connections. These shall conform to JSS no. 50815 design to meet the specification or equivalent.
- 4.14 System shall have real time clock for recording date & time.

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4.15 Environmental conditions:

4.15.1 The equipment shall be capable of operating efficiently in spite of dust, dirt, mist, torrential rains, heavy sand or snow storms, presence of oil vapors and radiant heat etc., to which rolling stock is normally exposed in service. The equipments shall be suitable for traction application under the following environmental conditions.

<p>➤ Atmospheric temperature</p>	<p>Maximum temperature: 50 degree Celsius</p> <p>Maximum touch temperature of metallic surface under the Sun: 75 degree Celsius and in shade: 55 degree Celsius</p> <p>Maximum temperature near electronic cards in un-energised condition of locomotive standing under direct sunlight during summer: 70 degree Celsius</p> <p>Maximum temperature near electronic cards in working condition of locomotive during summer: 65 degree Celsius</p> <p>Minimum temperature: - 10 degree Celsius ( Also snow fall in certain areas during winter season)</p>
<p>➤ Humidity</p>	<p>100% saturation during rainy season</p>
<p>➤ Reference site conditions</p>	<p>i) Ambient temperature: 50 degree celsius</p> <p>ii) Humidity: 100%</p> <p>iii) Altitude: 1776 m above mean sea level</p>
<p>➤ Rain fall</p>	<p>Very heavy in certain areas.</p>
<p>➤ Atmospheric</p>	<p>Extremely dusty and desert terrain in certain</p>

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conditions	areas. The dust concentration in air may reach a high value of 1.6 mg/m <sup>3</sup> . In many iron ore and coal mine areas, the dust concentration is very high affecting the filter and air ventilation system
➤ Coastal area	humid and salt laden atmosphere with maximum pH value of 8.5, Sulphate of 7 mg per liter, maximum concentration of chlorine 6 mg per liters and maximum conductivity of 130 micro siemens / cm
➤ Wind speed	High wind speed in certain areas, with wind pressure reaching 150 kg/m <sup>2</sup>

#### 4.15.1.1 Vibration & Shock:

The RRCS shall be designed to withstand the vibrations and shock encountered in service satisfactorily as specified in IEC 61373 and IECs as applicable to other equipments.

#### 4.15.1.2 Electromagnetic and Radio Frequency Interference Pollution

High degree of electromagnetic pollution is anticipated in locomotive machine room, where the equipment shall be mounted. Necessary precaution shall be taken in this regard. The Contractor shall test the actual level of EMI in locomotive and design the system accordingly. Railways shall provide all necessary assistance for such measurement. The RRCS shall be interference free and same shall be tested as per IEC 60571 and IEC 61000 for Electro Magnetic Compatibility.

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## CHAPTER - V

## TESTING, PROVING AND FIELD TRIALS

## 5.0 CATEGORIES OF TEST

5.1 Following are the type of tests to be carried out on the equipment to be supplied against this specification.

## 5.1.1 TYPE TESTS

5.1.1.1 Type tests shall be carried out on equipment of the approved design. If there is any change in the design or source of supply of any components/sub-assembly/assembly, units made to the changed design or from new source shall be treated as new item for the purpose of conducting type tests.

5.1.1.2 Type tests are to be repeated in case of any major change is made. In case of minor changes, i.e., change in type, rating of component etc special test/tests as agreed by Purchaser and Contractor are to be conducted to ensure their suitability and effectiveness of the modifications.


5.1.1.3 The type tests shall be repeated once in five years by RDSO and such test are termed as 'consistency type tests'.

## 5.1.2 ROUTINE TESTS

5.1.2.1 Routine tests shall be carried out on every equipment of each order.

## 5.1.3 ACCEPTANCE TESTS


Acceptance test shall be carried out on 10% of batch quantity subject to minimum of 4 numbers.

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## 5.2 TEST DETAILS:

The tests to be carried out on complete unit are given in the following table. Type and routine test schemes shall be prepared in accordance with the relevant specifications and furnished to RDSO for approval. Type test shall be conducted on the basis of the approved type test scheme in the presence of Inspecting Officers of RDSO/CLW/Railway representative. However, any additional test, if felt necessary shall also be conducted at the time of type test. Contractor shall bear the expenses of the tests.

Sl. No.	TESTS	Relevant Spec		To be carried out as		
		Spec	Clause No	Type test	Routine test	Acceptance test
1.	Visual Inspection	EC	10.2.1	✓	✓	✓
2.	Performance test	EC	10.2.2	✓	✓	✓
3.	Cooling Test	IEC	10.2.3	✓		
4.	Dry heat test	IEC	10.2.4	✓		
5.	Damp heat test	IEC	10.2.5	✓		
6.	Supply over voltage, Surges and	IEC 60571	10.2.6	✓		✓
7.	Transient burst susceptibility test	IEC 60571	10.2.7	✓		
8.	Radio interference test	IEC 60571	10.2.8	✓		
9.	Insulation test	IEC	10.2.9	✓	✓	✓
10.	Salt mist test	IEC	10.2.10	✓	✓	✓
11.	Vibration and shock test	IEC	-	✓		
12.	Water tightness test	IEC	10.2.12	✓		

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13	RDSO spec no ELRS/SPEC/SI/0015 of Oct 2001 for specification for reliability of electronics			✓		
14	Functional tests	As per clause no 5.3		✓		


### 5.3 FUNCTIONAL TESTS

Functional tests shall be carried out at the works of the Contractor and/or during trial fitment of equipment on locomotives. The purpose of these tests is to assess the functioning of the equipment, as per the functional requirements indicated in Chapter-III of this specification, before the equipment is cleared for field service trial. For this purpose, the contractor shall work out and propose the detailed testing methodology and same shall be finalized after approval of RDSO.


### 5.4 TESTS AND MONITORING DURING FIELD TRIALS

5.4.1 System shall be subjected to extensive field trials for a period of at least six months after fitment on locomotives. During field trials operation of the system shall be checked for all functional requirements mentioned in Chapter III of this specification which shall necessarily include following checks;


- a) Performance of the system in long curved tunnels.
- b) Performance of the system in ghat section with heavy cuttings.
- c) Performance of the system when two RRCS operated trains passes each other. In this test it shall be checked whether system in remote loco in one train responds to commands of lead loco of another train.
- d) Time delay in response of system on remote loco to a command from lead loco.
- e) Feedback of each response by system on remote loco to system of leading loco. This test shall have to be carried out for every single command.
- f) Performance of the system for negotiating Neutral Section and restrictions of lowering of pantographs.

Radio Remote Control System For WAG-9/WAG-9H Three Phase Locomotive	PREP.BY. SSE/D&D	CHECKED BY AFF/D&D	 CENTRE FOR DESIGN & DEVELOPMENT CHITTARANJAN LOCOMOTIVE WORKS WEST BENGAL, INDIA NO: CLWC-D&D/ES/3/ 0540			
	APPROVED BY. DY. CEE/CON/TU-II		ALT.			

- 5.4.2 As the system is expected to give smoother train operation and reduction of coupler forces, RDSO shall also arrange coupler force trials at Railway's cost to verify this aspect.
- 5.4.3 RDSO shall prescribe additional tests/trials based on the experience of product, development/trials for proving the intended performance of the product.

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# ANNEXURE - I

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Vehicle Control Software

## IR WAP-5/WAG-9

### Design FG 07 - Master State Control

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## 07.1. Purpose

This design paper explains in a first step all states (or nodes) and the corresponding transitions (or conditions) to jump to the next state. The master state controls and coordinates all processors. It controls the general actions of the vehicle, like self test, set up, shutdown, driving. This Function group is built as a sequential state control program. The drawing in the appendix gives the graphical overview with the corresponding node numbers and transition numbers.

## 07.2. Reference Documents

[1] Vehicle Control Software - Specification ( 211.02 ) 3EHP 541 681 V B

## 07.3. Processors and Clusters

All processors containing this function group are listed below.

Processor	Description
FLG1/ FLG2	Master State Control (or Master Flow Chart)

## 07.4. Normal Functionality

### 07.4.1. General Information

The master state control is on vehicle control level. This means, the master state control is responsible for each loco itself. All functions and sub state controls in all other processors are controlled by the MSC.

### 07.4.2. Redundancy

The complete functiongroup is redundant in processor FLG2.

### 07.4.3. Starting up of MSC

After the key switch is turned to driving position, MSC starts functioning only after diagnostic reset is done.

### 07.4.4. Commands

Different commands that are generated corresponding to different MSC nodes for different processors are summarised in different segments.

#### **07.4.5. Shutdown (Nodes in sequence: 12,13 or 600, 601, 612, 613)**

(VCB off, Pantograph down, DClink circuit deenergised) Executed once for a disturbance that persists even after shutdown.

MSC commands MCE to turn off after 10 minutes if :

- none of the cab is occupied
- more than 1 cab is occupied
- in multiple operation, only one of the two locos is in simulation mode
- pantograph is down (Inhibited in trailing mode & simulation mode)

MSC commands MCE to turn off immediately if :

- Incompatible software
- battery voltage falls below 82 volts

MSC commands for a shutdown & goes to node 504 ( cab still occupied ) if :

- Emergency stop push button is pressed
- Subsystem 01(main power) isolation demanded

If for example the key switch is turned off and the driver does not acknowledge a disturbance, MCE must switch off after 10 minutes . This means that if MSC is in any of the shutdown nodes, it does not jump to any of the disturbance nodes (exception of SLG1 or SLG2 commanding a protective turn off. Then MSC goes to disturbance node & after protective turn off it goes back to shutdown nodes).

MSC can go to shutdown nodes directly only with the following transitions :

- from node 71 to node 12,
- from node 701, 715, 716 to 600 or
- from node 503 to 600 (Only if cab is not occupied).

#### **07.4.6. Timeout**

At various states of MSC different commands are given to SLG1/2. Before proceeding MSC checks the feedbacks from SLG1/2. If the expected feedback is not received within 30 sec. VCB trips & MSC goes into disturbance node & a fault is indicated. Acknowledgement of fault leads to isolation of SLG1 or SLG2 whichever is malfunctioning. If the feedback expected during a shutdown is not received on time MSC jumps to next shutdown node and not to disturbance node (except there is a protective turn off command from from SLG1 or 2).

However during switchover from FLG1 to FLG2 (FLG1 lifesign disturbed and before push button fault acknowledge is pressed, signal FLG2\_54-PFLG2MastRq is true) the timeouts are suppressed by the signal 54-BFLG2MastRq.

From every node even if there is a timeout it must be possible (especially if key switch is turned off) to reach node 612 and to switch off MCE after 10 minutes without drivers action.

#### **07.4.7. Summarised signals**

Signals for commanding VCB to turn on & pantograph to raise & the feedback 'VCB is on' from various processors are summarised in this function group

**07.4.8. State description of MSC**

Node Nr.	Description
<b>0001</b>	Start node; first node after MCE activation
Transition Nr.	Transition description
T1.2	Direct

Node Nr.	Description
<b>0002</b>	Vehicle Bus Monitor; the communication to all processors is monitored
Transition Nr.	Transition description
T2.70	Vehicle Bus not ok; If after 10s, at least one processor live signal is found disturbed (FG10)
T2.10	Vehicle Bus ok, within 10s all members (FLG1/2, HBB1/2, STB1/2, BUR1/2/3, DDA1/2 SLG1/2) have started to answer

Node Nr.	Description
<b>0010</b>	Release process to processor SLG1 & SLG2
Transition Nr.	Transition description
T10.70	Disturbance with VCB off or without VCB off ( 54-MVCBOfWiDis or 54-MDisWoVCBOf ) Priority 1 fault
T10.110	End of initialisation( 08-MInitEnd )

Node Nr.	Description
<b>0012</b>	MCE starts 'Switch off timer'
Transition Nr.	Transition description
T12.2	Cab active in train & no shutdown requests
T12.13	Shutdown request (see 07.4.5.)

<b>Node Nr.</b>	<b>Description</b>
<b>0013</b>	MCE switches off (Command FLG:07-BMCE-Off)

<b>ode Nr.</b>	<b>Description</b>
<b>0070</b>	Disturbance with or without VCB off (Priority 1 fault)
<b>Transition Nr.</b>	<b>Transition description</b>
T70.71	Fault recognised, stepping MSC (FG54)

<b>Node Nr.</b>	<b>Description</b>
<b>0071</b>	FLG ready for acknowledge; Protective action executed
<b>Transition Nr.</b>	<b>Transition description</b>
T71.2	Fault acknowledged
T71.12	Any shutdown request ( see 07.4.5)

<b>Node Nr.</b>	<b>Description</b>
<b>0110</b>	Test periphery SLG1 (Command FLG: 07-BPeriTstB1)
<b>Transition Nr.</b>	<b>Transition description</b>
T110.70	Disturbance with or without VCB off (Priority 1 fault)
T110.120	Test ok (SLG1: 08-MPeriTstEnd) or bogie 1 isolated

<b>Node Nr.</b>	<b>Description</b>
<b>0120</b>	Test periphery SLG2 (Command FLG: 07-BPeriTstB2)
<b>Transition Nr.</b>	<b>Transition description</b>
T120.70	Disturbance with or without VCB off (Priority 1 fault)
T120.310	Test ok (SLG2: 08-MPeriTstEnd) or bogie 2 isolated



<b>Node Nr.</b>	<b>Description</b>
<b>0310</b>	Release Test 1 ALG1 (Command FLG: 07-BALGTst1B1)
<b>Transition Nr.</b>	<b>Transition description</b>
T310.70	Disturbance with or without VCB off (Priority 1 fault)
T310.320	Test 1 ALG1 successful (SLG1: 08-MALGTst1End) or bogie 1 isolated (FG54)

<b>Node Nr.</b>	<b>Description</b>
<b>0320</b>	Release Test 1 ALG2 (Command FLG: 07-BALGTst1B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T320.70	Disturbance with or without VCB off (Priority 1 fault)
T320.350	Test 1 ALG2 successful (SLG2: 08-MALGTst1End) or bogie 2 isolated (FG54)

<b>Node Nr.</b>	<b>Description</b>
<b>0350</b>	Release Test 2 ALG1 (Command FLG: 07-BALGTst2B1)
<b>Transition Nr.</b>	<b>Transition description</b>
T350.70	Disturbance with or without VCB off (Priority 1 fault)
T350.351	Test 2 ALG1 successful (SLG1: 08-MALGTst2End) or bogie 1 isolated (FG54)

<b>Node Nr.</b>	<b>Description</b>
<b>0351</b>	Release Test 2 ALG2 (Command FLG: 07-BALGTst2B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T351.70	Disturbance with or without VCB off (Priority 1 fault)
T351.390	Test 2 ALG2 successful (SLG2: 08-MALGTst2End) or bogie 2 isolated (FG54)

<b>Node Nr.</b>	<b>Description</b>
<b>0390</b>	ALG ready ( Command FLG1/2 : 07-BALGReadyB1/B2 )
<b>Transition Nr.</b>	<b>Transition description</b>
T390.70	Disturbance with or without VCB off (Priority 1 fault)
T390.503	ALG ready

<b>Node Nr.</b>	<b>Description</b>
<b>0503</b>	Loco ready for setup, cab not active
<b>Transition Nr.</b>	<b>Transition description</b>
T503.710	Disturbance with VCB off (FG54)
T503.700	Disturbance without VCB off(FG54)
T503.600	No Cab active in train.
T503.504	Cab activated in train (on the loco or multiple unit)

<b>Node Nr.</b>	<b>Description</b>
<b>0504</b>	Cab active, Key switch in Pos."D" (Multiple operation: Cab on slave loco active)
<b>Transition Nr.</b>	<b>Transition description</b>
T504.710	Disturbance with VCB off (FG54)
T504.700	Disturbance without VCB off (FG54)
T504.550	Driver's wish: Pan up & SS01 not off
T504.600	Panto is down since 10 minutes
T504.503	Cab not active in train

<b>Node Nr.</b>	<b>Description</b>
<b>0550</b>	Pantograph up enable
<b>Transition Nr.</b>	<b>Transition description</b>
T550.710	Disturbance with VCB off (FG54)
T550.700	Disturbance without VCB off (FG54)
T550.605	DC-Link prepare pre-charging ready (SLG 1 or 2: 08-MDCLCprprRd)
T550.560	Driver's wish: VCB close (criteria line voltage ok is tested in FG32 of STB1/HBB1)
T550.504	Driver's wish: Pan down or SS01 isolated

<b>Node Nr.</b>	<b>Description</b>
<b>0560</b>	VCB enable
<b>Transition Nr.</b>	<b>Transition description</b>
T560.710	Disturbance with VCB off (FG54)
T560.700	Disturbance without VCB off (FG54)
T560.570	Feedback from FG32: VCB is closed
T560.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

<b>Node Nr.</b>	<b>Description</b>
<b>0570</b>	VCB closed (Command FLG: 07-BExPTSConB1/B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T570.710	Disturbance with VCB off (FG54)
T570.700	Disturbance without VCB off (FG54)
T570.580	Driving direction selected & external protective shut down connected (SLG 1 and 2: 08-MExPTSCon) and pressure ist main reservoir is okay
T570.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

<b>Node Nr.</b>	<b>Description</b>
<b>0580</b>	Gate Unit Bogie 1 enable (Command FLG: 07-BGUSP-OnB1)
<b>Transition Nr.</b>	<b>Transition description</b>
T580.710	Disturbance with VCB off (FG54)
T580.700	Disturbance without VCB off (FG54)
T580.581	Gate Unit Bogie 1 is on (SLG1: 08-MGUSP-OnEnd) or bogie 1 off
T580.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

<b>Node Nr.</b>	<b>Description</b>
<b>0581</b>	Gate Unit Bogie 2 enable (Command FLG: 07-BGUSP-OnB2)
<b>Transition Nr.</b>	<b>Transition description</b>
T581.710	Disturbance with VCB off (FG54)
T581.700	Disturbance without VCB off (FG54)
T581.583	Gate Unit Bogie 2 is on (SLG2: 08-MGUSP-OnEnd) or bogie 2 off
T581.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

<b>Node Nr.</b>	<b>Description</b>
<b>0583</b>	DC-Link precharging (Command FLG: 07-BDCLCsetB1/B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T583.710	Disturbance with VCB off (FG54)
T583.700	Disturbance without VCB off (FG54)
T583.584	DC-Link precharged (SLG1&2: 08-MDCLCsetEnd) or bogie 1 or 2 off
T583.550	Driver's wish: VCB open (Master or Slave loco) or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0584</b>	Release converter contactor bogie 1 (Command FLG: 07-BCvConOnB1)
Transition Nr.	Transition description
T584.710	Disturbance with VCB off (FG54)
T584.700	Disturbance without VCB off (FG54)
T584.585	Converter contactor bogie1 closed (SLG1: 08-MCvConOnEnd) or bogie 1 off
T584.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0585</b>	Release converter contactor bogie 2 (Command FLG: 07-BCvConOnB2)
Transition Nr.	Transition description
T585.710	Disturbance with VCB off (FG54)
T585.700	Disturbance without VCB off (FG54)
T585.590	Converter contactor bogie2 closed (SLG2: 08-MCvConOnEnd) or bogie 2 off
T585.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0590</b>	DC-Link ready (Command FLG: 07-BPulsEnblB1/B2)
Transition Nr.	Transition description
T590.710	Disturbance with VCB off (FG54)
T590.700	Disturbance without VCB off (FG54)
T590.592	TE/BE demand from throttle > 0% and throttle was in zero position and no traction interlock of bogie1 & bogie2 and bogie 1 & 2 not off & Bogie1 & 2: NSC pulsing released (SLG1&2: 08-MPulsEnbl)
T590.570	Speed = 0km/h & reverser in position 'Neutral'
T590.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0592</b>	Configuration Harmonic Filter(Command FLG: 07-BFiltConfB1/B2, true only if filter is on)
Transition Nr.	Transition description
T592.710	Disturbance with VCB off (FG54)
T592.700	Disturbance without VCB off (FG54)
T592.594	TE/BE demand from throttle > 0% and no traction interlock of bogie1 and bogie2 and bogie 1 & 2 not off and Filter configuration end (SLG1 or SLG2 : 85-MFiltConfig) or filter off temporarily
T592.590	Reverser in position neutral & speed = 0km/h, or TE/BE demand from throttle = 0%
T592.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0594</b>	NSC pulsing (Command FLG: 07-BNSC-PulsB1/B2, true only if there is no traction interlock B1/B2)
Transition Nr.	Transition description
T594.710	Disturbance with VCB off (FG54)
T594.700	Disturbance without VCB off (FG54)
T594.596	TE/BE demand from throttle > 0% and no traction interlock of bogie1 and bogie2 and bogie 1 & 2 not off and NSC1 & 2 is pulsing (SLG1&2: 08-MNSC-Puls)
T594.592	Reverser in position 'Neutral' & speed = 0km/h or TE/BE demand from throttle = 0%
T594.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0596</b>	NSC & ASC pulsing, Traction motors magnetised, TE/BE effort enable (Command FLG: 07-BNSC-PulsB1/B2 , 07-BASC-PulB1/B2, true only if there is no traction interlock B1/B2)
<b>Transition Nr.</b>	<b>Transition description</b> :The transitions are true only if TE/BE demand from FG46 is 0kN
T596.710	Disturbance with VCB off (FG54)
T596.700	Disturbance without VCB off (FG54)
T596.594	Reverser in position 'Neutral' & speed = 0km/h or TE/BE demand from throttle = 0% for 10 sec. & speed = 0km/h
T596.550	Driver's wish: VCB open or VCB off without disturbance (FG 32)

Node Nr.	Description
<b>0600</b>	VCB off , Panto Down
<b>Transition Nr.</b>	<b>Transition description</b>
T600.710	Disturbance with VCB off (FG54) & protective turn off
T600.601	Primary voltage = 0 (Panto Down ) & VCB off or VCB stuck on & SLG has shut down released or subsystem 01 off or timeout of (SLG1&2:08-MShutDownEn)

Node Nr.	Description
<b>0601</b>	Shut Down Loco , DC link deenergising (Command FLG: 07-BShutDownB1/B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T601.710	Disturbance with VCB off (FG54) & protective turn off
T601.612	DC-Link deenergised or timeout of (SLG1&2 : 08-BShutDownEd)

<b>Node Nr.</b>	<b>Description</b>
<b>0605</b>	DC - Link voltage too low. prepare precharging(Command FLG:07-BDCLCpchgB1/B2)
<b>Transition Nr.</b>	<b>Transition description</b>
T605.710	Disturbance with VCB off (FG54)
T605.700	Disturbance with out VCB off (FG54)
T605.550	DC-Link prepare precharging ok or timeout of (08-MDCLCprprEd)

<b>Node Nr.</b>	<b>Description</b>
<b>0612</b>	MCE starts 'switch off timer'
<b>Transition Nr.</b>	<b>Transition description</b>
T612.710	Disturbance with VCB off (FG54) & protective turn off
T612.613	Shutdown request (see 07.4.5.)
T612.504	Cab active in train and no shutdown requests

<b>Node Nr.</b>	<b>Description</b>
<b>0613</b>	MCE switches off (Command FLG:07-BMCE-Off)

<b>Node Nr.</b>	<b>Description</b>
<b>0700</b>	Disturbance without VCB off
<b>Transition Nr.</b>	<b>Transition description</b>
T700.710	Disturbance with VCB off (FG54)
T700.701	Fault recognised, stepping MSC (FG54)



Node Nr.	Description
<b>0701</b>	Loco ready again
Transition Nr.	Transition description
T701.710	Disturbance with VCB off (FG54)
T701.600	Any shutdown request (see 07.4.5.)
T701.560	Fault acknowledged

Node Nr.	Description
<b>0710</b>	Disturbance with VCB off
Transition Nr.	Transition description
T710.715	Fault recognised, stepping MSC (FG54)

Node Nr.	Description
<b>0715</b>	Loco Ready for VCB on
Transition Nr.	Transition description
T715.716	Protective turn off (SLG1&2 : 08-MPTOActEnbl ) & command: 09-BPTO
T715.600	Any shut down request (see 07.4.5.)
T715.550	Fault acknowledge

Node Nr.	Description
<b>0716</b>	Protective shut-down activated through SLG1/2 (Command FLG: 07-BPTOActB1/B2)
Transition Nr.	Transition description
T716.600	Shut down request & protective turn off action end
T716.550	Protective turn off action end (SLG1 & 2: 08-MPTOActEnd) and fault acknowledged

### 07.5. Multiple Control

Multiple Control does not affect this FG.

## 07.6. Disturbances

In case of disturbance the master state chart behaves as follows

MSC present node	Disturbance	Next node sequence
002-390	disturbance without VCB off	070 / 071
002-390	disturbance with VCB off	070 / 071
503-596	disturbance without VCB off	700 / 701
503-596, 700-701	disturbance with VCB off	710 / 715 / 716
600-612	disturbance with VCB off only if SLG commands protective turn off	710 / 715 / 716

## 07.7. Interface

Below is a complete list of all input and output signals of this function group, ordered by cluster.

### 07.7.1. FG07-implemented in FLG1/2

Cluster Task: 100 ms

Signalname	Type	I/O	Bustype	From / To	Description
07-XNodeMSC	GO	O	MVB	ALL	Actual node MSC
07-BPeriTstB1/B2	Bit	O	MVB	SLG1/2	Command periphery test bogie 1/2
07-BALGTst1B1	Bit	O	MVB	SLG1	Command ALG test 1 bogie 1
07-BALGTst1B2	Bit	O	MVB	SLG2	Command ALG test 1 bogie 2
07-BALGTst2B1	Bit	O	MVB	SLG1	Command ALG test 2 bogie 1
07-BALGTst2B2	Bit	O	MVB	SLG2	Command ALG test 2 bogie 2
07-BALGReadyB1	Bit	O	MVB	SLG1	Command ALG ready bogie1
07-BALGReadyB2	Bit	O	MVB	SLG2	Command ALG ready bogie2
07-BExPTSConB1/B2	Bit	O	MVB	SLG1/2	Command connect external protective shut down bogie 1/2
07-BGUSP-OnB1	Bit	O	MVB	SLG1	Command gate unit supply on bogie 1
07-BGUSP-OnB2	Bit	O	MVB	SLG2	Command gate unit supply on bogie 2
07-BDCLCsetB1	Bit	O	MVB	SLG1	Command DC link circuit setup bogie1
07-BDCLCsetB2	Bit	O	MVB	SLG2	Command DC link circuit setup bogie2
07-BCvConOnB1	Bit	O	MVB	SLG1	Command converter contactor on bogie 1
07-BCvConOnB2	Bit	O	MVB	SLG2	Command converter contactor on bogie 2
07-BPulsEnblB1	Bit	O	MVB	SLG1	Command pulsing enable bogie 1
07-BPulsEnblB2	Bit	O	MVB	SLG2	Command pulsing enable bogie 2
07-BFiltConfB1	Bit	O	MVB	SLG1	Command configurate filter bogie 1
07-BFiltConfB2	Bit	O	MVB	SLG2	Command configurate filter bogie 2
07-BNSC-PulsB1	Bit	O	MVB	SLG1	Command NSC pulsing bogie1
07-BNSC-PulsB2	Bit	O	MVB	SLG2	Command NSC pulsing bogie2
07-BASC-PulsB1	Bit	O	MVB	SLG1	Command ASC pulsing bogie1
07-BASC-PulsB2	Bit	O	MVB	SLG2	Command ASC pulsing bogie2
07-BShutDownB1	Bit	O	MVB	SLG1	Command shut down bogie1
07-BShutDownB2	Bit	O	MVB	SLG2	Command shut down bogie2
07-BDCLCprprB1	Bit	O	MVB	SLG1	Command DC link circuit prepare precharge bogie1
07-BDCLCprprB2	Bit	O	MVB	SLG2	Command DC link circuit prepare precharge bogie2
07-BPTOActB1	Bit	O	MVB	SLG1	Command protective turn off action bogie1
07-BPTOActB2	Bit	O	MVB	SLG2	Command protective turn off action bogie2
07-BMCE-Off	Bit	O	MVB	STB1, HBB1	Command turn off MCE
07-MVCBOn	Bit	O	MVB INT	SLG1, SLG2 FG 06	Message VCB is on
07-BVCBOn	Bit	O	MVB	SLG1, SLG2	Command VCB on
07-BPantoUp	Bit	O	MVB	SLG1, SLG2	Command panto up
07-MToXXXXX	Bit	O	INT	FG 06	Timeout for feedback from SLG1/2
07-BRelFitAck	Bit	I	INT	FG14	Relay fault acknowledge for slave loc

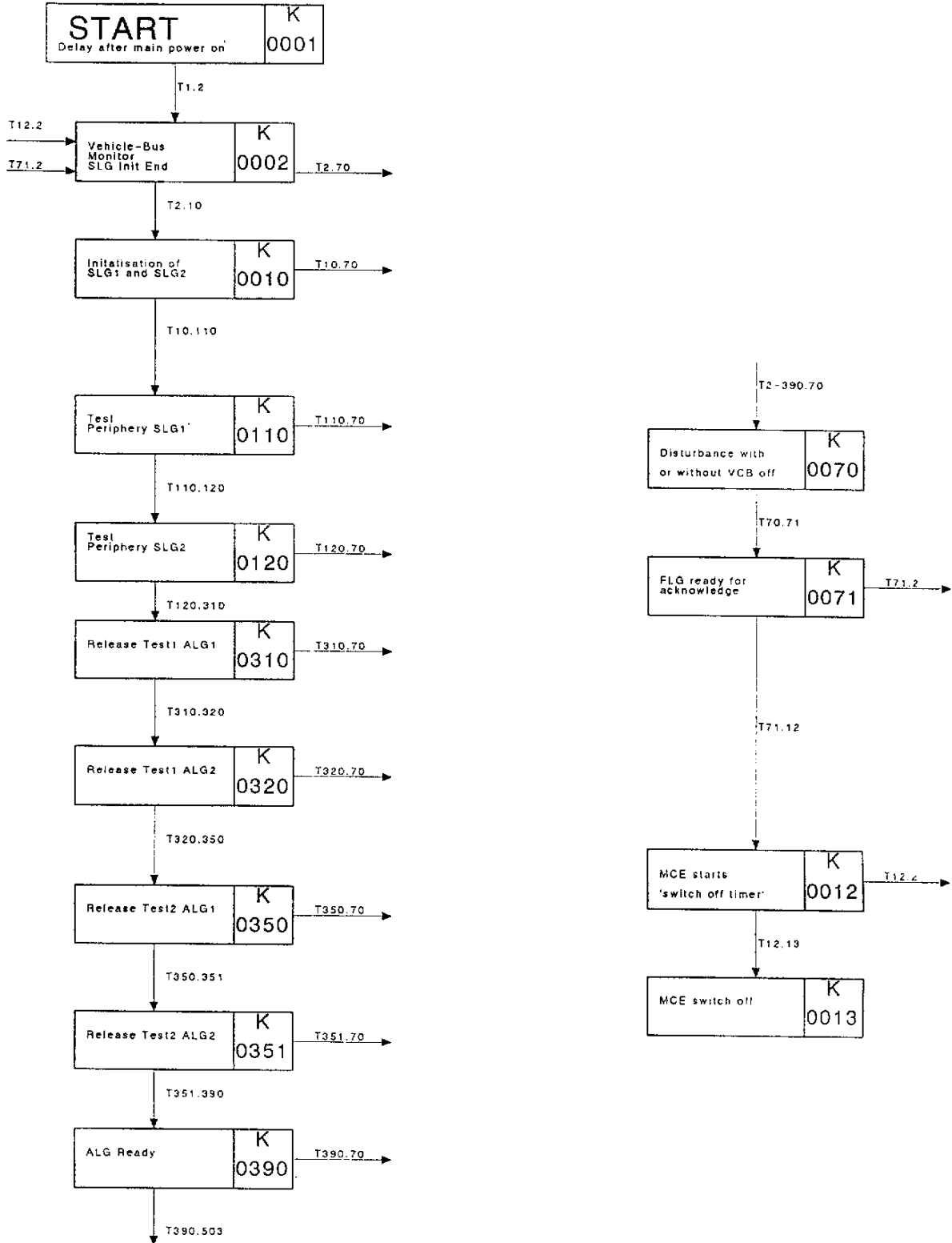
07-MToB1	Bit	O	INT	FG 06	Timeout for feedback from SLG1 (summarised)
07-MToB2	Bit	O	INT	FG 06	Timeout for feedback from SLG2 (summarised)
07-BPanShDown	Bit	O	INT	FG 06	Shut down - panto low for 10 mins.
00-BInitSubabl	Bit	I	INT	FG00	Initialize sub state control
00-DiagReset	Bit	I	INT	FG00	Reset diagnostic control
54-MVCBOfWiDis	Bit	I	INT	FG54	Disturbance with VCB off
32-MVCBOfWoDis	Bit	I	MVB	FG32 HBB1/STB1	Disturbance without VCB off
54-MDisWoVCBOf	Bit	I	INT	FG54	Disturbance without VCB off
43-MEmgStopShDn	Bit	I	INT	FG43	Emergency stop
23-MCbFitShDwn	Bit	I	INT	FG23	More than one cab occupied
23-MTrainOccup	Bit	I	INT	FG23	One cab occupied
11-MTbDistMast	Bit	I	INT	FG11	Train bus disturbed
13-BRelFitAck	Bit	I	INT	FG13	Relay fault acknowledge from master
18-BSimulation	Bit	I	INT	FG18	Simulation is active
09-MUprimOK	Bit	I	INT	FG09	Primary voltage OK
18-BDisSimShDn	Bit	I	INT	FG18	Both locos not in simulation mode
26-M590&thr=0	Bit	I	INT	FG26	Node 590 and throttle in 0 position
77-MBatLowShDn	Bit	I	MVB	FG87 BUR2	Battery voltage low
77-MBatLowShDn	Bit	I	MVB	FG87 BUR3	Battery voltage low
10-MMVB-Ok	Bit	I	INT	FG10	Vehicle bus ok
50-XSpeedTrain	Analog	I	INT	FG50	Actual value train speed
54-BSteppinMSC	Bit	I	INT	FG54	Stepping MSC
54-BFaultAck	Bit	I	INT	FG54	Failure reset (F.Acknowledge)
54-MTrailMode	Bit	I	INT	FG54	Trailing mode active
54-BSubSxx-Off	Bit	I	INT	FG54	div. Subsystems isolated
54-BxxxxOffDem	Bit	I	INT	FG54	div. Proc. isolation demanded
46-WTE/BE-B1/2=0kN	Bit	I	INT	FG46	TE/BE demand = 0
47-MDirecSelec	Bit	I	INT	FG47	Direction of motion selected
00-MSWMisMSLG1/2	Bit	I	INT	FG00	Software mismatch
49-BTE/BEILkB1/2	Bit	I	INT	FG49	Traction interlock bogie1/2
32-MVCB-On	Bit	I	MVB	FG32,HBB1 /STB1	VCB closed
32-MVCBStuckOn	Bit	I	MVB	FG32,HBB1 /STB1	VCB stuck on
32-LVCBOnWish	Bit	I	MVB	FG32 HBB1 /STB1	Driver's wish VCB on
32-LVCBOffWish	Bit	I	MVB	FG32 HBB1 /STB1	VCB off
01-LActKSwC	Bit	I	MVB	FG01 STB1/STB2	Key switch cab activated
31-BPanUp	Bit	I	MVB	FG31 HBB2 /STB2	Command Pan up
31-LPanUpWish	Bit	I	MVB	FG31 HBB2 /STB2	Driver's wish Pan up
31-LPanDnWish	Bit	I	MVB	FG31 HBB2 /STB2	Pan down
01-MPrSwLowMR	Bit	I	MVB	FG01 HBB2	Pressure switch (pressure in main reservoir is .low)
53-BASRPuls	Bit	I	MVB	FG53 HBB2 /STB2	ASR pulsing
54-BFLG2MastRq	Bit	I	INT	FG54	FLG2 master request (True only in FLG2)
08-MInitEnd	Bit	I	MVB	FG08 SLG1/SLG2	SLG initialisation end
08-MPeriTstEnd	Bit	I	MVB	FG08 SLG1/SLG2	SLG periphery test end
08-MALGTst1End	Bit	I	MVB	FG08 SLG1/SLG2	ALG test 1 end
08-MALGTst2End	Bit	I	MVB	FG08 SLG1/SLG2	ALG test 2 end
08-MALGReady	Bit	I	MVB	FG08 SLG1/SLG2	ALG ready
08-MExPTSCon	Bit	I	MVB	FG08 SLG1/SLG2	External protective shutdown connected
08-MGUSP-OnEnd	Bit	I	MVB	FG08 SLG1/SLG2	Gate unit supply on end

08-MDCLCsetEnd	Bit	I	MVB	FG08 SLG1/SLG2	DC link circuit setup end
08-MCvConOnEnd	Bit	I	MVB	FG08 SLG1/SLG2	Converter contactor on end
85-MFiltConfig	Bit	I	MVB	FG08 SLG1/SLG2	Filter configured
85-MFiltOffTmpry	Bit	I	MVB	FG08 SLG1/SLG2	Filter temporarily off
85-BFiltMAstB1/2	Bit	I	INT	FG85	Bogie ½ is master for filter
85-BFiltOff	Bit	I	INT	FG85	Filter is off
08-MPulsEnbl	Bit	I	MVB	FG08 SLG1/SLG2	Pulsing enable
08-MNSC-Puls	Bit	I	MVB	FG08 SLG1/SLG2	NSC is pulsing
08-MASC-Puls	Bit	I	MVB	FG08 SLG1/SLG2	ASC is pulsing
08-MShutDownEn	Bit	I	MVB	FG08 SLG1/SLG2	Shut down release end
08-MShutDownEd	Bit	I	MVB	FG08 SLG1/SLG2	Shut down end
09-BPTO	Bit	I	MVB	FG08 SLG1/SLG2	Protective turn off
08-MDCLCprprRd	Bit	I	MVB	FG08 SLG1/SLG2	DC link precharge ready
08-MDCLCprprEd	Bit	I	MVB	FG08 SLG1/SLG2	DC link precharge end
08-MPTOActEnbl	Bit	I	MVB	FG08 SLG1/SLG2	Protective turn off action enable
08-MPTOActEnd	Bit	I	MVB	FG08 SLG1/SLG2	Protective turn off action end

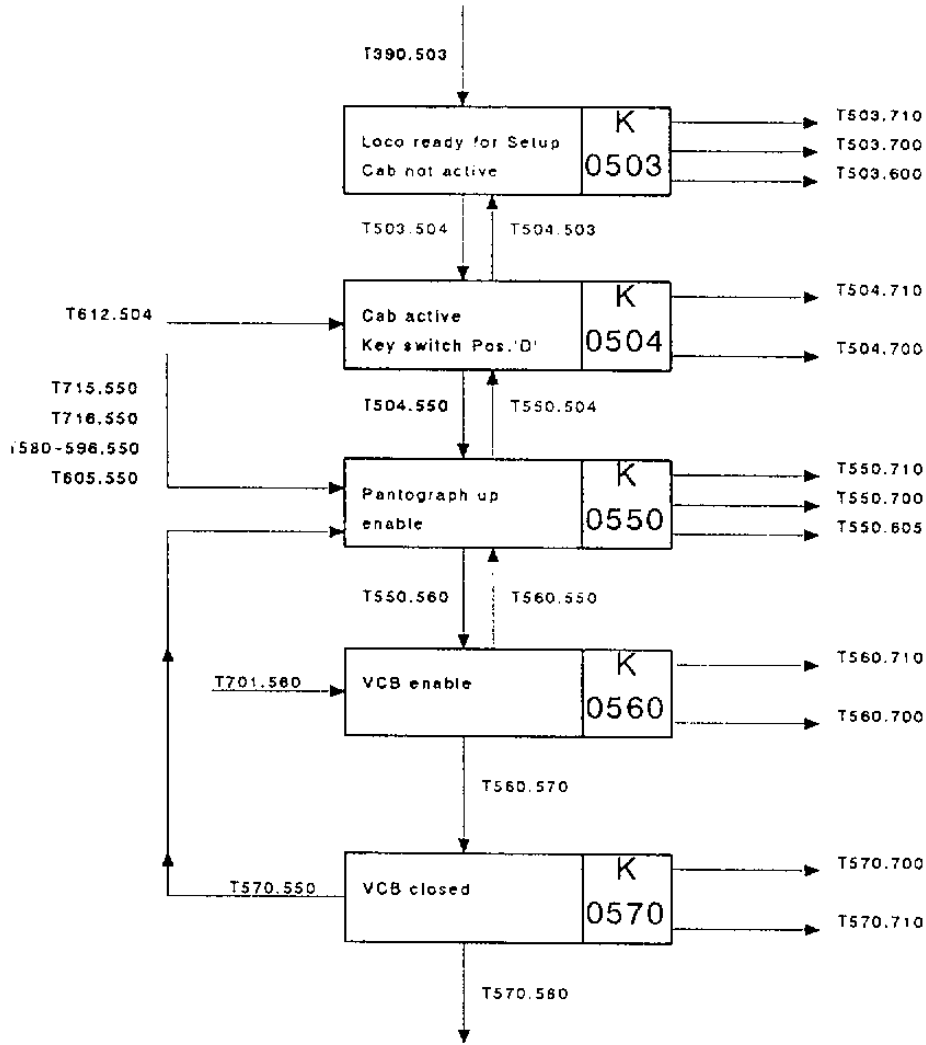
## 07.8. Appendix Principle-Scheme

Principle schemes of this FG are given in appendix.

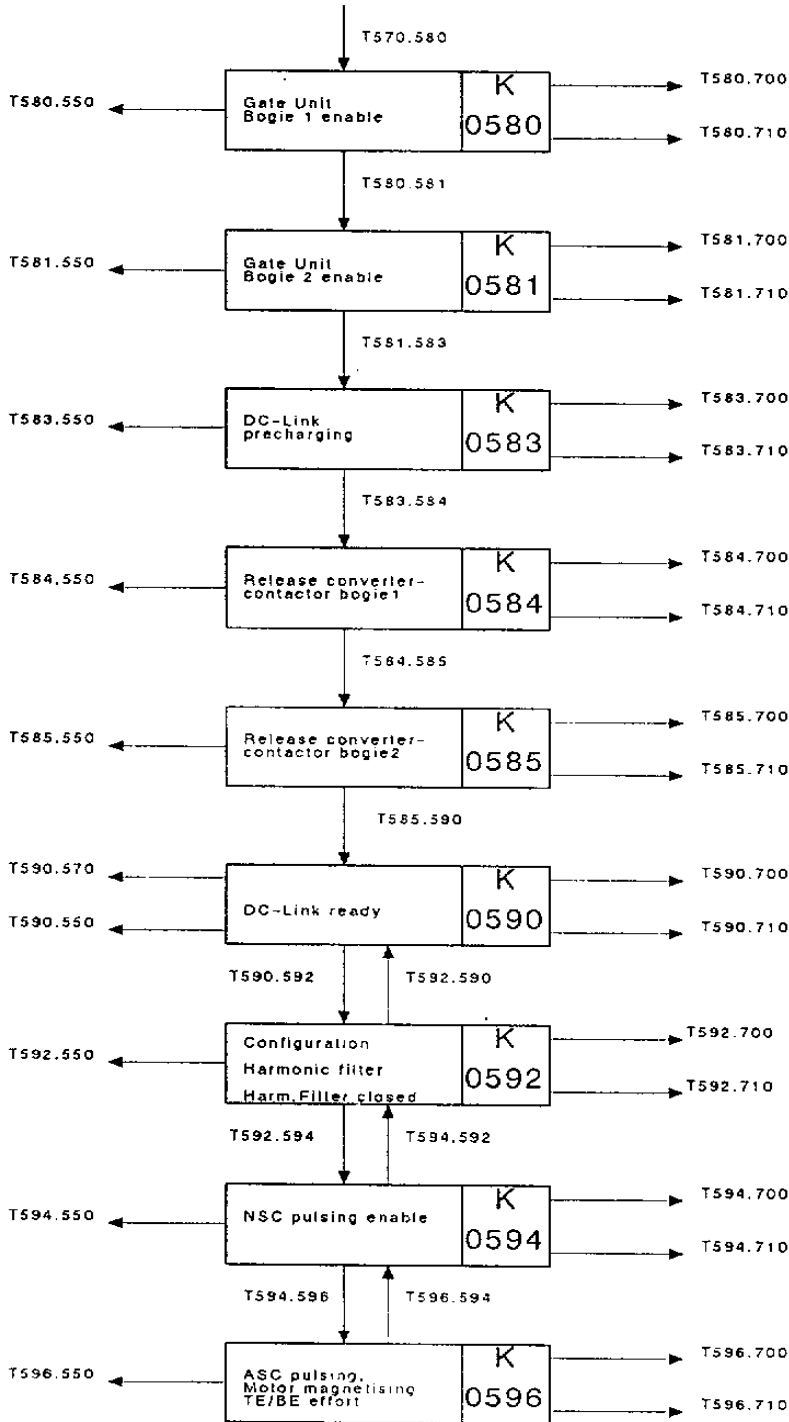
Initialisation, Lifesign test, Periphery and ALG test of SLG



Activate cab, raise pan, close VCB



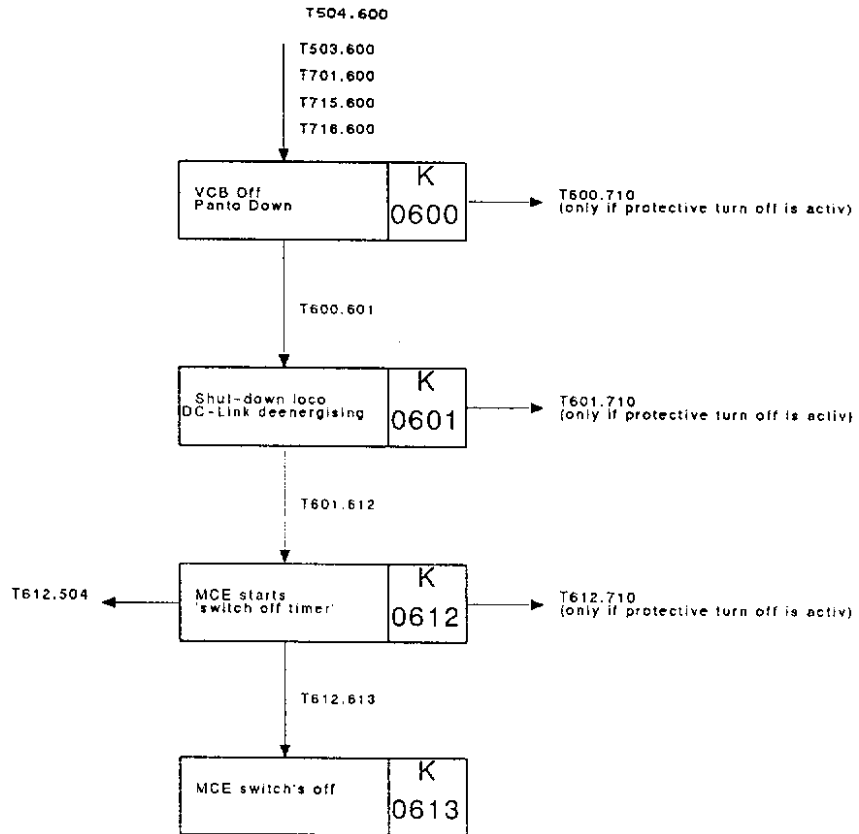
Set up converters for traction





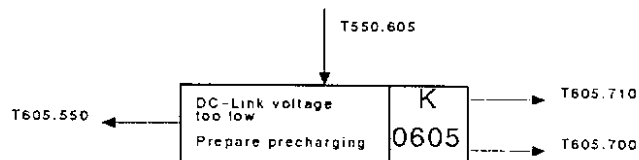
**Shut-down:**

VCB open, Pan down, DC-link deenergised, MCE off



**Prepare precharging DC link**

(If DC link is charged & VCB goes off & DC link voltage falls below a certain level)





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