SPECIFICATION FOR
TCN BASED VEHICLE CONTROL UNIT (VCU)
FOR THREE PHASE LOCOMOTIVES

SPECIFICATION No. CLW/C-D&D/ES/3/TCN_VCU/0547
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### SPECIFICATION

**FOR**
- TCN BASED VEHICLE
- CONTROL UNIT (VCU)
- FOR
- 3 PHASE LOCOMOTIVES

**PREP. BY**
- SSE/D&D

**CHKD/REV**
- AEE/D&D

**ISSUED BY**
- DY. CEE / D&D

**CENTER FOR DESIGN & DEVELOPMENT**

**CHITTARANJAN LOCOMOTIVE WORKS.**

**WEST BENGAL, INDIA**

**NO. CLW/C-D&D/ES:3/TCN-VCU/0547**
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CHAPTER 1 - GENERAL

1.0 Foreword

Presently, Indian Railways manufacture WAG9, WAG-9H, WAP-7 (Co-Co) and WAP-5 (Bo-Bo), type 3-phase electric locomotives. These locomotives employ a distributed architecture for control and data communication using MICAS-S2 (Micro Computer Automation System – series 2) which is proprietary in nature. The whole control system has the following bus stations for managing the functions of the vehicle.

- Vehicle Control Unit (1 & 2)
- Converter Control Electronics (1 & 2)
- Auxiliary Converter Electronics (1, 2 & 3)

In order to sustain the control system in a rolling stock during its lifetime, i.e. over 35 years, it becomes necessary to update the technology continuously and tackle the obsolescence. Also to ensure interchangeability of control electronics from various sources, need was felt to standardize the control hardware and software. In this context, Indian Railways in association with Centre for Development of Advanced Computing (CDAC), Thiruvananthapuram developed indigenously, using state-of-the-art hardware and software, an open architecture technology for functional equivalent of Vehicle Control Unit. IEC has published a standard for open control architecture in rail vehicle, viz IEC-61375, which is termed as TCN. The design is based on Train Communication Network (TCN) specification. It defines the requirements of various layers of communication and interface.

1.1 Scope and object

This specification covers the technical aspects of Indian Railway’s requirement for the Vehicle Control Unit (VCU) to be used in WAG9, WAG-9H, WAP-7 (Co-Co) and WAP-5 (Bo-Bo) type 3-phase electric locomotives. It also explains interface requirement and desired performance attributes. It attempts to clarify the testing methodology, wherever user’s discretion is involved. Relevant IEC standards will be the governing specification in rest of the cases.

1.2 Applicable Normative Standards

- IEC 60571 - Rules for electronic equipment onboard rail vehicles (General)
- IEC 60068 - Environmental test procedure
- IEC 61373 - Vibration test procedure
- IEC 62236 - 3-2 - EMI/EMC test procedure
- IEC 61000-4-5 - Surges test procedure
- IEC 61375 - Train communication network (TCN)
- IEC 61131 - Programming Languages for PLCs (ISaGRAF).

1.3 Reference documents for Racks & PCBs

The latest and updated TOT documentation would contain all the required information for the manufacturing and testing of the Electronic Cards, the VCU Racks and the other accessories as given in the Scope of supply of this tender.
The racks must be supplied fully wired and tested condition, including the flange casing, ready to mount on loco floor.

1.4 Warranty

The suppliers shall be responsible for any damage of the equipments provided in the locomotive due to defective materials, workmanship up to a period of 36 months after commissioning on the locomotive, or 42 months from the supply, whichever is earlier. The supplier shall replace all such equipment during the warranty period at his own cost. The period of warranty will be extendable in case of recurring problems attributable to defective material or manufacturing.

The supplier shall be responsible for carrying out all the modifications at his own cost on any part of the equipment during the period of warranty. For any technical decision the final authority from the purchaser’s side is RDSO & CLW.
CHAPTER 2- TECHNICAL SPECIFICATION

2.0 Structure of Vehicle Control System

The vehicle control system of the complete locomotive shall be in the form of two VCU modules that would be installed in vertically standing cubicles in the machine room of the locomotive. The hardware architecture and rolling stock software distribution of the system is given in Fig 1. SR1/2 represent the main converter modules and BUR1/2/3 represent the auxiliary converter modules.

Fig1: VCU Architecture and Rolling Stock Software Distribution
The details of functional equivalent systems in new VCU against the legacy MICAS system is listed in the table below.

<table>
<thead>
<tr>
<th>Processor Cards (new VCU)</th>
<th>Functional systems (MICAS VCU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCU_APP 1 New Application processor (Incorporating FLG&amp;STB functions)</td>
<td>FLG Vehicle control</td>
</tr>
<tr>
<td>VCU_APP 2 New Application processor (Incorporating HBB&amp;DDA functions)</td>
<td>STB Low voltage cubicle control</td>
</tr>
<tr>
<td>BA MVB administrator</td>
<td>HBB Auxiliary cubicle control</td>
</tr>
<tr>
<td>Display Driver display with MVB (Incorporating Display &amp; DIA function)</td>
<td>DDA Display controller</td>
</tr>
<tr>
<td></td>
<td>BA MVB administrator</td>
</tr>
<tr>
<td></td>
<td>DIA Diagnostic processor</td>
</tr>
<tr>
<td></td>
<td>WTB WIRE TRAIN BUS interface module with Administrator</td>
</tr>
</tbody>
</table>

2.1 System Description

VCU (1&2) hardware is integrated in Euro racks with 6U height and 104T width with an integrated heat exchanger and fan unit. The rack allocation of VCU subsystems is given in Fig.2. For each processor segment, there is a Controller Area Network (CAN) bus for interfacing I/O segments. A wired MVB redundant bus in the backplane connects different processor segments. Some PCB slots in the VCU rack are kept as spare slots for future use and also to retain the IO connection form factor.

Each VCU has two power supplies respectively in slots AB & CD. Locomotive battery, which is 110V DC (nominal), provides the input for the power supply cards. Some of the PCBs in VCU racks are fed from both power supplies for redundancy purpose.

Slot-E contains a signal routing board for connecting the analog input and output signals through front sub-D connectors. After signal conditioning, these signals are routed to analog I/O card at the adjacent Slot-F through backplane PCB. The analog I/O card has CAN interface for I/O data connectivity to the rolling stock application processor.

Application Processor-1 which functions as the main vehicle computer FLG and low voltage cubicle controller STB, resides in Slot-G. This card has CAN interface for I/O connectivity and MVB interface for TCN protocol. Application processor card is main controller for VCU-TCN application.

Slots H and I are spare slots.

Two digital I/O boards with CAN interface occupy Slots J and L respectively. These boards process I/O signals corresponding to STB 1 & 2 functions of the locomotive through front sub-D connectors. These cards connect the I/O signals to the Application processor over the CAN interface via backplane.
Slots M & N are spare slots.

A passive temperature sensor is provided in slot-K. This PCB is only holding a passive thermostat. The thermostat is filled with a fluid and has a capillary in it connected to a thermostat switch. The purpose is to activate the thermostat switch when the temperature reaches 70°C. The capillary is brought out through the front plate of the PCB. The thermostat switch is mounted outside the VCU rack. The thermostat, thermostat switch, capillary tube etc. is within the scope of Supply.

Two digital I/O boards with CAN interface occupy Slots O and Q respectively. These boards process the I/O signals corresponding to HBB 1 & 2 functions of the locomotive through front sub-D connectors. The cards connects the I/O signals to the Application processor over the CAN interface via backplane. Slots P & R are spare slots.

Application Processor-2 resides in Slot-S, which functions as Auxiliary cubicle controller, HBB and Driver Display Adapter (DDA). This card has CAN interface for I/O connectivity and MVB interface for TCN protocol. Application processor card is main controller for VCU-TCN application.

MVB bus administrator, which is basically an Application Processor occupies Slot-T and is responsible for the MVB bus traffic administration. This is having high-performance embedded PowerPC processor and a Cyclone III FPGA based MVB controller.

![Fig2: The rack allocation of VCU](image)

A multi-redundant bus coupler (Star Coupler) at Slot-V couples the other VCU as well as other bus-stations like SR1/SR2, BUR1/2 & 3, over fibre optic MVB interface. This card also has an MVB ESD service connector for interfacing suitable development system.
(PC/Laptop) for VCU configuration and commissioning. MVB Driver Display Unit also will be connected to VCU using the coupler via FOC or service connector with suitable amplifier.

Driver Display Unit in Cab2 functions as the diagnostic computer for storing *diagnostic messages* in the new VCU, replacing the DIA processor PPA624A01 in MICAS system. Both driver displays will be interfaced with VCU using MVB interface in the new system.

Wire Train Bus (WTB) for interconnecting Vehicles. This provides intervehicular communication during multiple operations. Presently, train bus interface is provided with off the shelf WTB module which is to be connected to VCU MVB.

All PCBs are 6U high, 234mm deep and are mechanically polarized for specific slots in VCU rack. They have mechanical stiffener for withstanding vibration & safety earth contact for rack insertion. Input D connectors, in PCBs are also mechanically polarized to prevent false connections. The front cover of the rack should be removable easily using a screwdriver.

**Each VCU consist of following items (Bill of Materials):**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Description</th>
<th>Quantity/VCU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Application Processor PCB</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Digital I/O PCB (110V digital inputs, Potential free digital outputs - relay contacts)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Analog I/O PCB</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Analog Routing PCB (+/- 20V analog inputs)</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>MVB Administrator</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>MVB Coupler (5 FOC interface &amp; 1 ESD interface)</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Temperature sensor Interface</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Back Plane PCB</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>SMPS PCB (110V DC input)</td>
<td>2</td>
</tr>
</tbody>
</table>

II Rack and accessories  6U height 104T width

III Heat Sink

IV Fan Assembly 48 V DC input, 3x 5W

V Mechanical enclosure - In MS with Zinc passivation. Form factor for one to one replacement of MICAS VCU.

### Functional Requirement:

The bus stations VCU1 and VCU2 in the control cubicles together with the auxiliary equipment listed shall perform following functions:

- Control of whole locomotive
- Interface to Aux. Converters BUR 1, BUR 2 and BUR 3
- Interface to main converter controllers SR 1 and SR 2
- Interface to drivers cab through driver display, meters, indicators, switches etc.
- Interface of pneumatic block
- Control of all locomotive auxiliary systems
- Control of power supply
- Administration of Multifunctional Vehicle Bus (MVB) traffic
- Interface to wired train bus for multiple operations.

Hardware configuration of the control rack shall be capable of achieving 100% redundancy in the event of any processor card failure within the same rack. Any hardware modification required in the locomotive, in this regard, may be indicated by the Supplier. The SR1 and SR2 control the traction converter equipment. BUR1, BUR2 and BUR3 control the auxiliary converter.

2.3 Power Consumption

The power consumption of the Bus Stations VCU 1/2 is 61 W each (Typical)

2.4 Backward compatibility with MICAS-S2

The TCN VCU set along with driver display unit should be one to one replaceable with presently used MICAS VCU and driver display unit. MVB communication shall be configured with all the control system connected with VCU by MVB, applicable to 3-phase locomotive and compatible to presently used MICAS system or TCN system. However, for WTB interface both systems (loco) should have TCN VCU.

2.5 Driver Display Requirement

The legacy MICAS system uses a passive alpha numeric 2-line display which is connected to Vehicle control electronics via RS422 interface. The display computer PP B908A01 resides in Slot-H & I of MICAS VCU, functions as Driver Display Adapter (DDA).

In the new VCU, Application processor-2, performs the functions of the Driver Display adapter besides the HBB functions. This processor connects to the display in each cab over MVB. The service connector in the MVB coupler board can also be used to interface the display units to the VCU. In this case, a signal repeater can be used to amplify the MVB signals over the display MVB cable length. The DDS and DIA functionality shall be implemented in display module.

2.6 Reliability

The design, manufacture and execution of the equipment within the scope of supply shall aim for and attain high reliability. The system should conform to the normative standards wherever it is applicable. The latest and updated TOT documentation would contain all the required information for the manufacturing and testing of the system.

2.7 Indigenisation

Whenever, the supplier indigenises any item/part of the assembly, he must take prior approval of RDSO. The testing of the indigenised item will be governed by relevant IEC/specification.

Bill of materials clearly indicating the items indigenised should be submitted sufficiently in advance to the call for inspection. Further, following information should be submitted for the items indigenised.

- Original product specification

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<th>SPECIFICATION FOR TCN BASED VEHICLE CONTROL UNIT (VCU) FOR 3 PHASE LOCOMOTIVES</th>
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<th>CHKD/REV</th>
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<td>SSE/D&amp;D</td>
<td>AEE/D&amp;D</td>
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<tr>
<td>ISSUED BY</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>DY. CEE / D&amp;D</td>
<td></td>
</tr>
</tbody>
</table>

CENTER FOR DESIGN & DEVELOPMENT
CHITTARANJAN LOCOMOTIVE WORKS.
WEST BENGAL, INDIA
NO. CLW/C-D&D/ES/3/TCN-VCU/0547
• Tabular comparative statement of original items identified as equivalent
• Test report of reputed test houses to substantiate above data
• Internal test reports carried out to be witnessed by authorized railway personnel
• Vendor details and codification to trace items indigenised

If a vendor is changed or the manufacturing process is changed for an already approved indigenised item, fresh approval is required to be taken from RDSO.

2.8 Component Obsolescence Plan

Preference will be given to TOT partners who have the significant component engineering resources to resolve any future component obsolescence. The tenderer’s plan for component obsolescence should be clearly delineated in the tender.

2.9 Maximum mechanical dimension (envelope) of VCU housing Case:

Length - 760 mm
Width – 502 mm
Height – 560 mm.
CHAPTER 3- CLIMATIC & ENVIRONMENTAL CONDITION

3.0 The racks/cubicles are to be mounted in the SB1/SB2 cubicles in the machine room, where the present vehicle control units are mounted. The environmental severities will be as under:

3.1 Maximum temperature inside stabled Locomotive- under sun : 70 deg. C
   Maximum temperature inside working loco - Under shade : 55 deg. C

   (The equipment shall be able to start up at the maximum specified temperature inside the locomotive without any pre-cooling requirement.)
   Minimum temperature : 0 deg. C

3.2 Humidity : Upto 100% during rainy season.

3.3 Altitude : Upto 1000 m above mean Sea level.

3.4 Rainfall : Very heavy in certain areas.

3.5 Atmosphere during hot weather: Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/cub.

3.6 Coastal area: The equipment shall be designed to work in coastal area in humidity and salt laden and corrosive atmosphere. The maximum values of the condition will be as follows:
   a) Maximum pH value : 8.5.
   b) Sulphate : 7 mg per litre.
   c) Max. concentration of chlorine : 6 mg per litre.
   d) Maximum conductivity : 130 micro siemens /CM

3.7 Vibration: The equipment shall be designed to withstand the vibrations and shock encountered in service satisfactorily as specified in 60571.1(1998 - 02) (second edition) publication for the converter and electronic equipments respectively and relevant IECs as applicable to other equipment.

3.8 Electromagnetic Pollution – High degree of electromagnetic pollution is anticipated in the area, where the equipment is being mounted in the locomotive. Suitable precaution should be taken to ward off the interference.
CHAPTER 4 – SCOPE OF SUPPLY

4.0 Scope of Supply per Locomotive of Vehicle Control Unit.

- VCU1: Control rack, fan assembly, enclosure and heat exchanger.
- VCU2: Control rack, fan assembly, enclosure and heat exchanger.
- Thermostat relay and its connecting tube and other accessories.
- Heat exchanger mounted behind the rack for cooling as well as the cubicle fans etc. as per the relevant drawing.
- Driver Display Units having MVB interface for CAB1 and CAB2 (make CLW approved source).
- Wire Train Bus (WTB) interface Module & its Sub D.
- Training on assembly, testing, commissioning, operation, maintenance and repair to IR personnel (Ref. Clause 2.10).

Note: Bus Stations for BUR and SR is not in the scope of the present tender.
CHAPTER 5 – TESTS & TRIALS

5.0 The entire rack shall be subjected to type test according to IEC 60571. In case any of the PCBs or other sub-assembly has been indigenously developed which have not been type tested earlier, such PCBs and sub-assemblies must also be subjected to type tests. The following type tests shall be compulsorily carried out on racks and/or PCBs (as the case may be) on a prototype of the order quantity. Authorised representative of RDSO/CLW may also decide to carry out certain special tests on the equipment, which are not covered by relevant IEC specification. Manufacturer shall carry out the test as per mutually agreed test programme at his own cost.

5.1 On successful completion and passing of type tests, routine tests as mentioned in table below shall be done on the rest of the equipment. The supplier has to submit in advance the type test plan and get the approval of RDSO. The routine test plan shall however be submitted to CLW. Type test shall be carried out by RDSO and CLW. The electronic assembly or, if necessary, its sub-assembly or, if necessary its sub-assemblies shall be subjected to a complete examination of its performances in order to determine whether these correspond to the specifications. The test protocol for such test either on PCB or rack level shall be mutually agreed between RDSO & Supplier and got approved.

5.2 Routine tests are to be carried out to verify that properties of the product corresponding to those measured during type tests. Routine test are to be carried out by the manufacturer on each equipment. Routine test shall be witnessed by CLW.

5.3 The list of the tests as per IEC-60571 to be carried out on control electronics/PCBs is as follows:

<table>
<thead>
<tr>
<th>S.NO</th>
<th>TEST</th>
<th>CLAUSE NO. OF IEC60571.</th>
<th>TYPE TEST</th>
<th>ROUTINE TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Visual inspection</td>
<td>10.2.1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2.</td>
<td>Tolerance &amp; Dimension</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.</td>
<td>Performance test by fault simulation</td>
<td>10.2.2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4.</td>
<td>Cooling</td>
<td>10.2.3</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Dry heat test</td>
<td>10.2.4</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Damp heat test (cyclic)</td>
<td>10.2.5</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Supply overvoltage, surges and electrostatic discharge tests</td>
<td>10.2.6</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Transient burst susceptibility test</td>
<td>10.2.7</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Radio interference test</td>
<td>10.2.8</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Insulation Resistance</td>
<td>10.2.9</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>11.</td>
<td>Di Electric</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12.</td>
<td>Salt mist test</td>
<td>10.2.10</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Vibration and shock</td>
<td>10.2.11</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Equipment stress screening test (Burn-in test)</td>
<td>10.2.13 and as per burn-in cycle mentioned in Fig-3</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
5.4 The prototype VCU set shall be inspected & tested jointly by the engineers of CLW and RDSO at the manufacturer’s premises or at mutually decided venue where all the facilities shall be made available for carrying out the prototype test. The equipments shall be kept in field trials for a period of six months. The CLW/RDSO engineers shall associate and witness the tests in the locomotive also till they are successfully completed. Any defects noticed / design improvement found necessary as a result of the test / trial shall be carried out by the Supplier in the least possible time. Serial production shall only start after successful trial run on locomotive and clearance to this effect given by RDSO.

Necessary arrangement shall be made by the Supplier to carry out certain tests to establish conformance to specified requirements.

5.5 Type test shall be performed on one unit of given design to verify that the product meets the requirements specified and agreed upon between users & manufacturer. Subject to agreement between user and manufacturer, CLW at its discretion may carry some or all the type tests once in five years on sample basis so as to confirm the quality of the product. This shall be part of revalidation of vendor approval. Type test shall also be repeated in following cases:

- First time supply to IR.
- Modification of equipment, which is likely to affect its function.
- Failure or variations established during type or routine test.
- Resumption of production after an interruption of more than two years.
- At the time of indigenisation, if the bidder has supplied with foreign collaboration self systems / onwards in product originally.

5.6 “The type test shall be carried out for the equipment / sub-assembly indigenised. The type test on the full unit in the case of indigenisation shall be considered only if there is major design change.”

5.7 Routine tests are to be carried out to verify that properties of the product corresponding to those measured during type tests. Routine test are to be done by the manufacturer on each equipments.

5.8 Investigation tests are intended to obtain additional information regarding the performance of the product. They shall be specially requested either by the user or the manufacturer.

5.9 Authorised representative of CLW/RDSO may conduct surprise check on manufacturing process and quality control along with any of the test to ensure quality of product and its conformance to CLW’s specification.

5.10 Burn in test – The cards used on the equipment shall be subjected to burn-in test for atleast 80 hours as per the temperature cycle. The cards shall be kept energized during the test. Functional test of each card shall be carried out after the burn in test. (Pl. refer Clause 10.2.13 of IEC 60517). This shall be part of internal test by manufacturer, whose results shall be submitted during routine test.
5.11 Inspection

a) The type test shall be carried out jointly by RDSO and CLW.

b) The routine inspection will be carried out by authorized representative of CLW.

c) The Tenderer shall furnish the details of Indigenisation plan along with the offer. During the type test, the supplier shall produce the Bill of Materials along with sources from where each item is procured. In case any component is not from the approved source, the same must have the prior approval of RDSO.

d) All the instruments used for testing shall be duly calibrated. The calibration certificates are to be shown to inspecting authority on demand.