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ERL MAINTENANCE SUPPORT SDN BHD

(Company No. 498574-T)

E-MAS

Effective Railway Operations; Reliable System Maintenance

ROLLING STOCK DEPARTMENT

IN-HOUSE TECHNICAL INSTRUCTION

APC FUNCTION AND TROUBLESHOOTING GUIDELINE

Doc. No. R00.OMR.M92111.BT.1001.A

Certified to ISO 9001 : 2008
Cert. No. AR 2874

Release

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Amendments or additions to this procedure must be indicated with a vertical black line in the adjacent left margin.

Change Record and Configuration Control

Revision	Date	Modification	Name
A	07.10.10	New	Dzulfaqar

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1 Purpose

The purpose of this document is to provide overview and operational guideline on Auxiliary Power Converter (APC) components for repairing and troubleshooting tasks. This is an additional information and instruction to the existing Operation and Maintenance (O&M) manual.

2 Scope, Distribution & Access

This document shall be accessible for all RST maintenance personnel who are carrying out repairing and troubleshooting works on APC and its components. The scope is only limited for its purpose and not compliable for redesigning, modification or copywriting the system. The content only cover general description which written based on an APC training conducted by Michael Zsambok from 30th August 2010 to 3rd September 2010 in ERL depot. User must first understand the cause and consequences of his/her own negligent of safety and O&M aspects.

For complete documentation of the APC Operation and Maintenance (O&M) manual, please refer to these following manuals:

a. **APC General O&M** – R00_RSE_92110_NZ_0001_B_COM_auxcon_4054010700001
b. **Partlist** – R00_RSE_92110_YL_0001_B_parts_list
c. **SIBMON Manual** – R00_RSE_92110_YR_0001_A_SIBMON_27677V20611
d. **M1300 Manual** – R00_RSE_92110_YR_0002_A_Sibcos_M130027688V10611
e. **M9000 Manual** – R00_RSE_92110_YR_0003_A_Sibcos_M900027690V20611
f. **APC Wiring Diagram** – R00_RSE_92110_YS_0001_B_circuit_40107_G

3 General Safety Procedure

The APC is not automatically de-energised when the input voltage has been cut OFF. The capacitors retain dangerous residual voltages. Before starting any work, it must be ensured that the vehicle is de-energised and parked securely.

Do not touch the APC components before everything has being de-energised and earthed. Components located inside the systems are supplied with dangerous contact voltages. For this reason, only qualified staff may operate the APC.
Qualified staff are persons who, due to their education, experience and training, as well as knowledge of the appropriate standards, directives, accident prevention regulations and operating conditions, are authorised by those responsible for the safety of the components/system to perform the necessary activities. They are in a position, due to their knowledge, to recognise and avoid possible dangers. Among other things, knowledge of first aid measures and local rescue facilities is also necessary.

All of the following steps must be obeyed without exception during service and maintenance work:

1) Stop the APC operation by switching OFF the main switch lever and then Battery OFF button in the Driver Cab.
2) Plug out the train batteries connectors (both side of APCs).
3) Secure the APC against re-start by means of a clear warning sign or with locks and also secure the battery connector against reclosure.
4) Establish de-energised state by measuring these following points using a multimeter. The

voltage at the connection bolts may not exceed 50 V.
- 350 V AC X20.1 to 4 670 VDC
- E1 and E2 (Spherical earth)110 VDC
- X3:3 (+) and -X3:1 (-)

5) Earth and short-circuit the spherical earth's E1, E2 and E3 using earthing short-circuit kit. First connect E3, then E1 and E2 thereafter.
6) Wait for a discharge time of at least 5 minutes.
7) Cover or fence neighbouring energised components

4 Hardware Introduction

4.1 Power Components

The main function of APC is to provide 400V AC three phase and 110V DC to be supplied to other subsystems load. ERL train is designed to draw 25kV single phase as it power supply, therefore a voltage conversion was required to suit these consumers necessity. Further detail explanation on APC is described in Auxiliary Power Converter O&M manual, Doc. No. R00_RSE_92110_NZ_0001_B.

The APC power conversion comprise of 4QC, PWMI and BLG modules. These modules are fitted with IGBT as the main component to convert the voltage waveform.

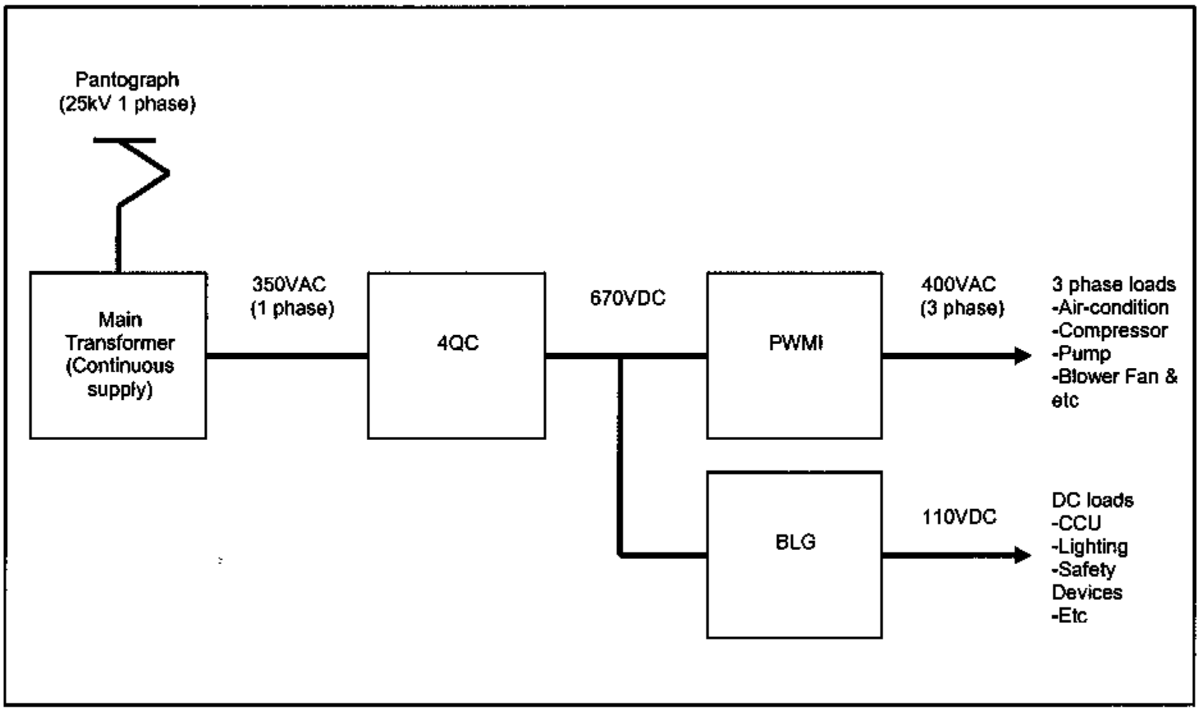


Figure 4.1: Voltage conversion block

These modules act as Stand Alone Unit meaning it decides either switch ON or OFF itself. Further explanation on this matter is described in item 4.4

4.1.1 Insulated-gate Bipolar Transistor (IGBT)

The insulated-gate bipolar transistor or IGBT is a three-terminal power semiconductor device, used for high efficiency and fast switching applications. Similar to transistor, it was designed to rapidly turn ON and OFF and commonly used in medium to high power applications.

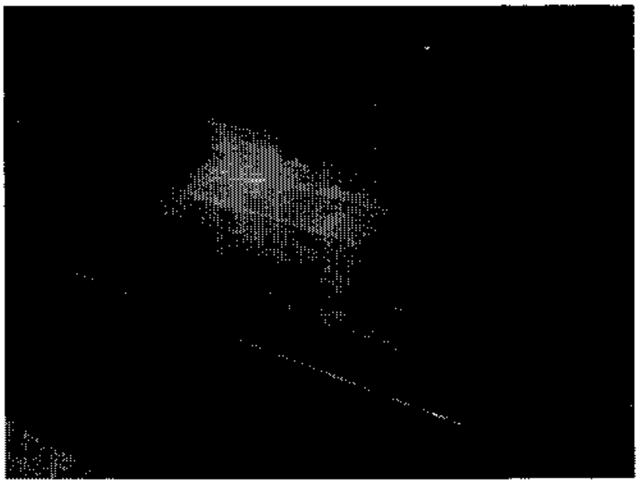


Figure 4.2: IGBT in APC modules

4.1.2 Four Quadrant Chopper (4QC)

4QC (also known as VQS or 4QS) is used to convert 350V RMS single phase from Main Transformer into 670V DC Link (Vp-p). This module replicate Boost Converter concept.

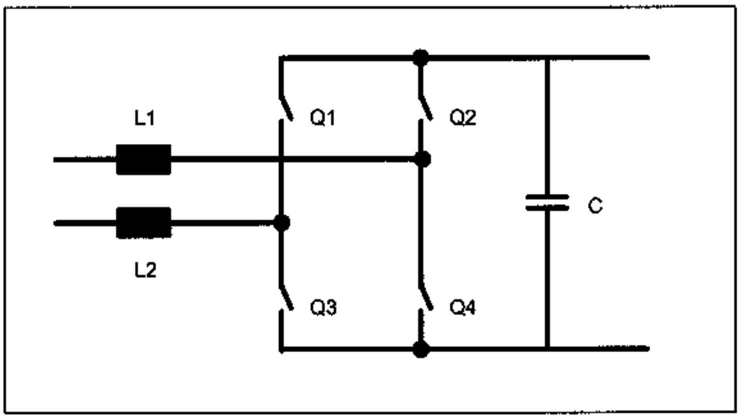


Figure 4.3: 4QC Block Diagram

This block comprises two modules, D1 (Master module) and G1 (Slave Module). The reason for using two modules is that one module cannot compensate the current needed by consumers and loads (eg: Aircond and battery charging current)

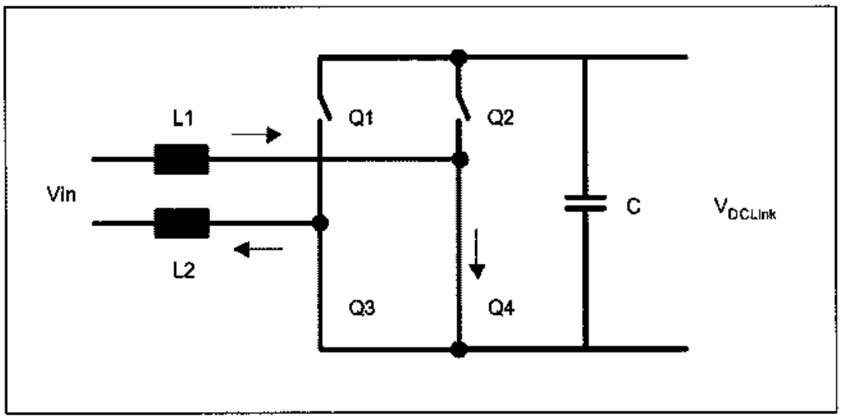


Figure 4.4: L1 and L2 Charging State

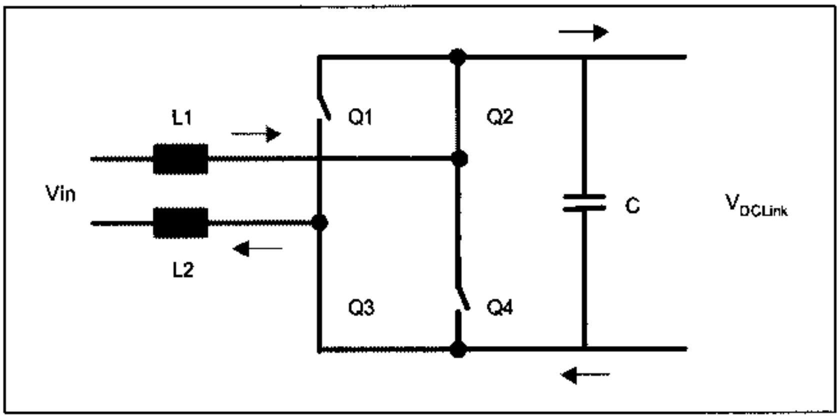


Figure 4.5: L1 and L2 Discharging State

During charging state (as shown in Figure 4.4), Q3 and Q4 closed creating a temporary short circuit looping in the 4QC module. This caused current surge through L1 and L2 (which located in Main Transformer) thus making L1 and L2 stored large amount of current.

During discharging state, (as shown in Figure 4.5), Q4 opened and Q2 closed, terminating the short circuit looping. At this time, L1 and L2 discharge the stored current. When this happened, the current from L1 and L2 mixed up with current from Vin. It can be interpreted in this simple calculation:

Voltage = Current x Resistance

V_{DCLink} = $(Current_{L1} + Current_{L2} + CurrentV_{in}) \times Resistance_{(from\ PWMI\ and\ BLG)}$

This explained why the DC Link voltage is higher that input voltage from Main Transformer.

This charging and discharging process is being repeated rapidly at 1000MHz. Therefore the short circuit condition during charging state is considered allowable and has no relation to permanent short circuit.

4.1.3 Pulse Width Modulator Inverter (PWMI)

PWMI is used to convert 670VDC Link voltage into 400VAC RMS 3 phase output for all motor consumer such blower fan and compressor (exclude traction motor). This block comprises two modules, J1 (Master module) and G1 (Slave Module). The reason for using two modules is that J1 only produce one phase while G1 produces another more two phases.

The PWMI operated by switching ON and OFF a single IGBT for certain period of time (known as pulsing width) as shown in figure 4.6. This allows certain amount of voltage passing through the IGBT and this process create the preferred sine waveform.

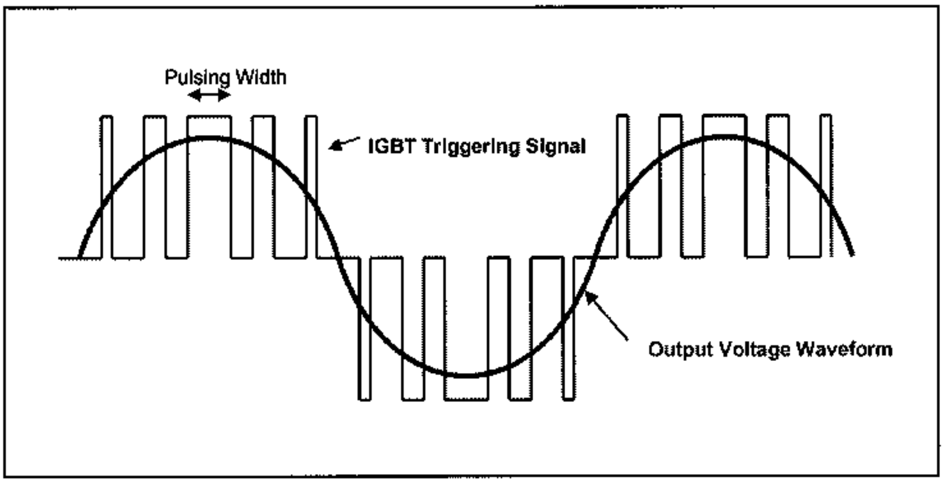


Figure 4.6: IGBT pulsing and output voltage waveform

The sine waveform is then combine with other IGBT to create 3-phase sine waveform. This is possible when three IGBTs triggered simultaneously.

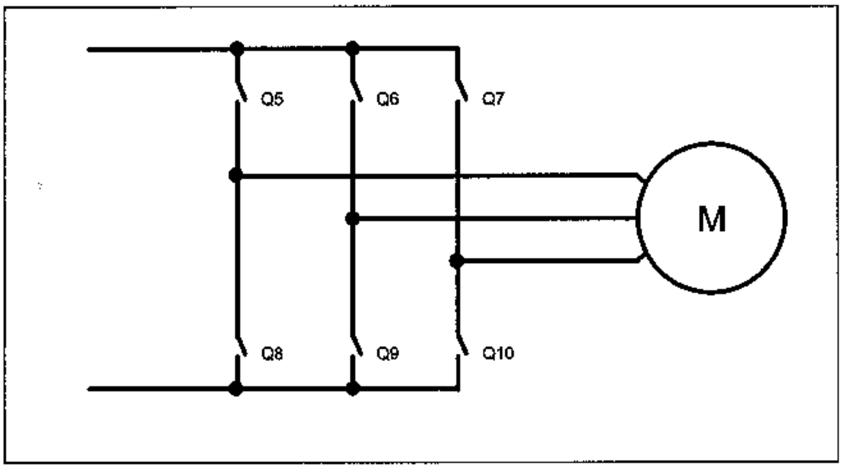


Figure 4.7: PWMI Block Diagram

One phase should be positive terminal and two more as negative terminal. For example, during U phasing, Q5 is closed connecting U Phase to positive terminal of the DC Link. Furthermore, Q9 and Q10 also closed connecting V Phase and W Phase to DC Link voltage negative terminal. Hence, making a complete circuit that connects the DC Link to 3-phase load. In order to create other phasing, this process was repeated using other combination of open-close IGBTs as shown on figure 4.8 to figure 4.10.

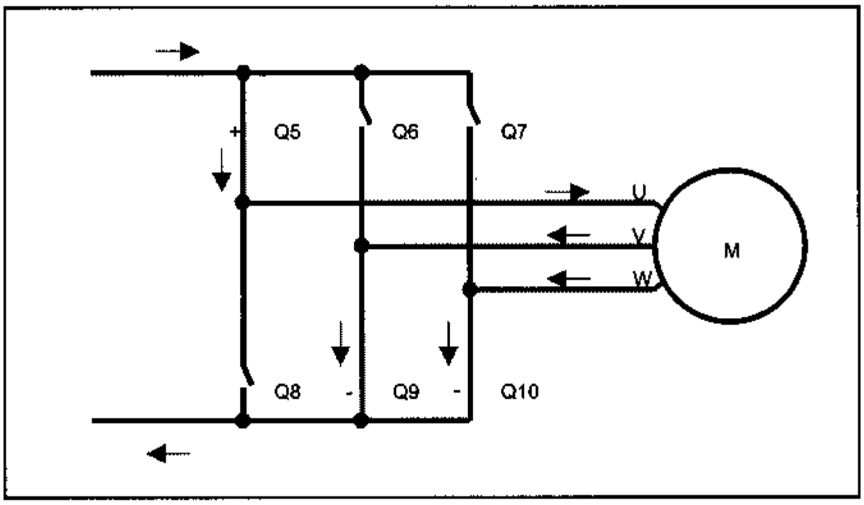


Figure 4.8: PWMI U Phasing

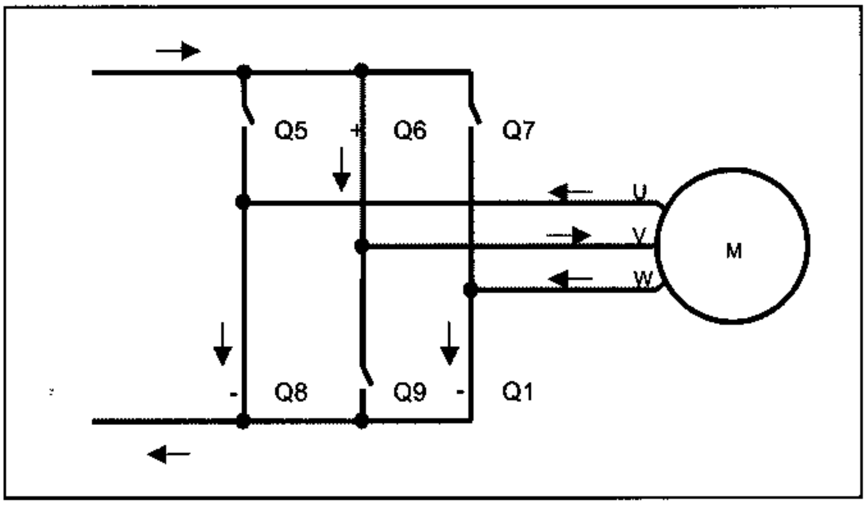


Figure 4.9: PWMI V Phasing

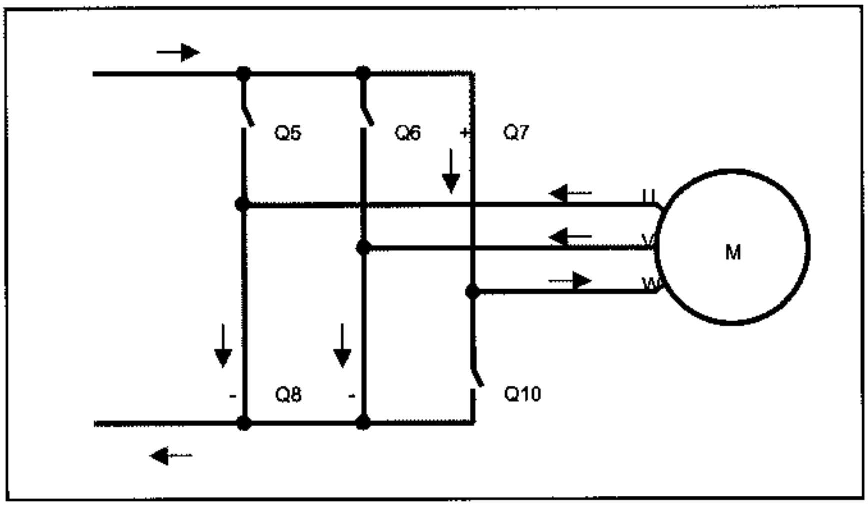


Figure 4.10: PWMI W Phasing

Since 3-phase consumers require 400V AC RMS (560V AC Vp-p), therefore higher DC Link voltage is required to cope this demand. Hence, this APC uses 670VDC as it DC Link value. Further electrical specification is described in Auxiliary Power Converter O&M manual, Doc. No. R00_RSE_92110_NZ_0001_B.

4.1.4 Battery Charger (BLG)

Battery Charger is used to produces 110V DC for lighting, control and instrumentation consumption and also to recharge the train battery. This block only comprises one module, which is the BLG. This module is connected directly to the train battery and supply 110VDC to certain consumers even though the train is shut down. All output is protected by fuses.

There are 3 types of BLG output:

i) Battery Direct (BD)
   - This output supplies 110VDC directly from battery and usually connected to safety instrument such Passenger Information System (PIS) and Brake Control Unit (BCU).

ii) Battery Normal (BN)
   - This output supplies 110VDC after A1K12 closed (Battery ON at Driver Cab pressed) from train battery to all the consumers including the APC controller itself, the M1300. This bypassed Battery Direct.

iii) Battery Clean (BC)
   - This supplies 110VDC after BLG supplied with DC Link Voltage and up running to all consumer. This bypassed Battery Normal.

Caution! Battery Direct and Battery Normal drains out the train battery voltage. Do not let these supply prolonged than needed.

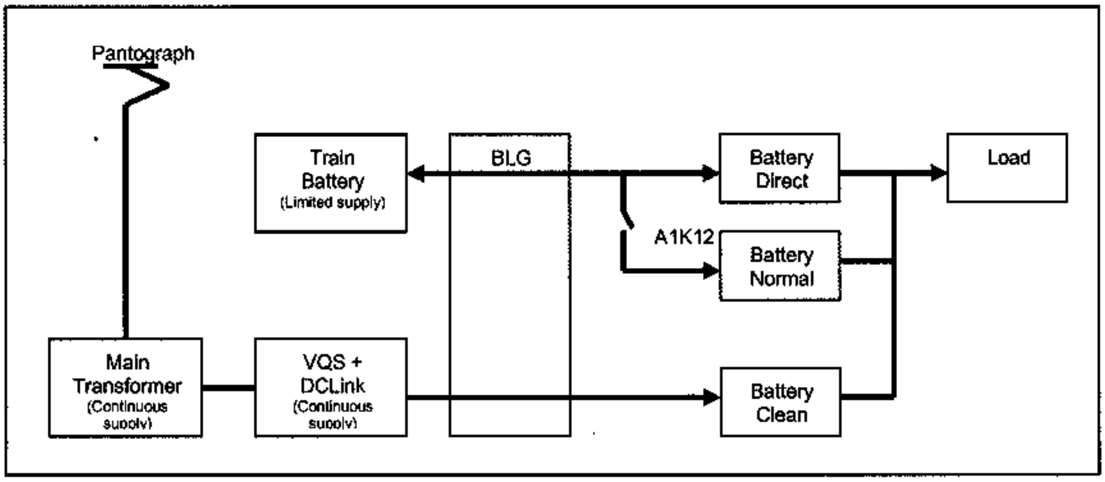


Figure 4.11: BLG Supply Management

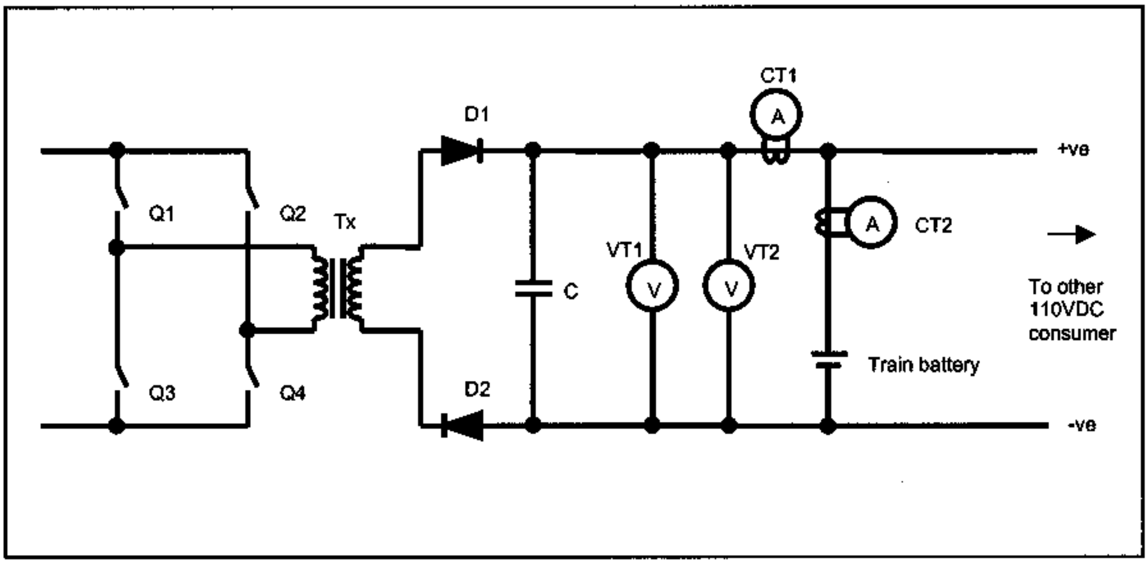


Figure 4.12: BLG Block Diagram

Similar to PWMI operation, the BLG turn ON and OFF certain IGBTs combination to invert the DC Link voltage into AC waveform. A transformer is used to step-down that voltage. It then converted back to DC by diode and Capacitors.

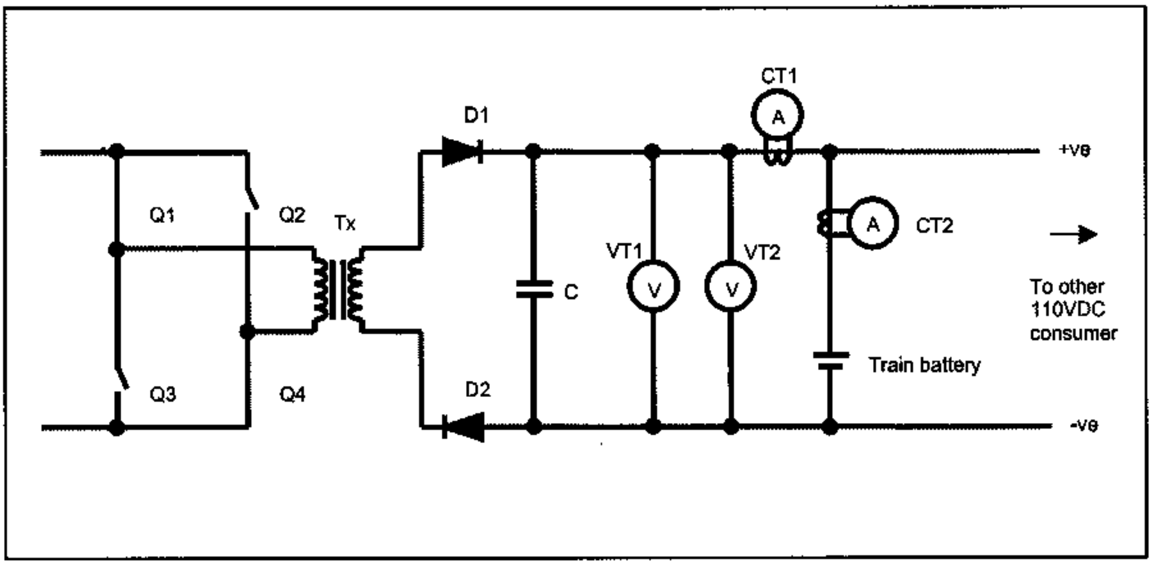


Figure 4.13: BLG positive cycle looping

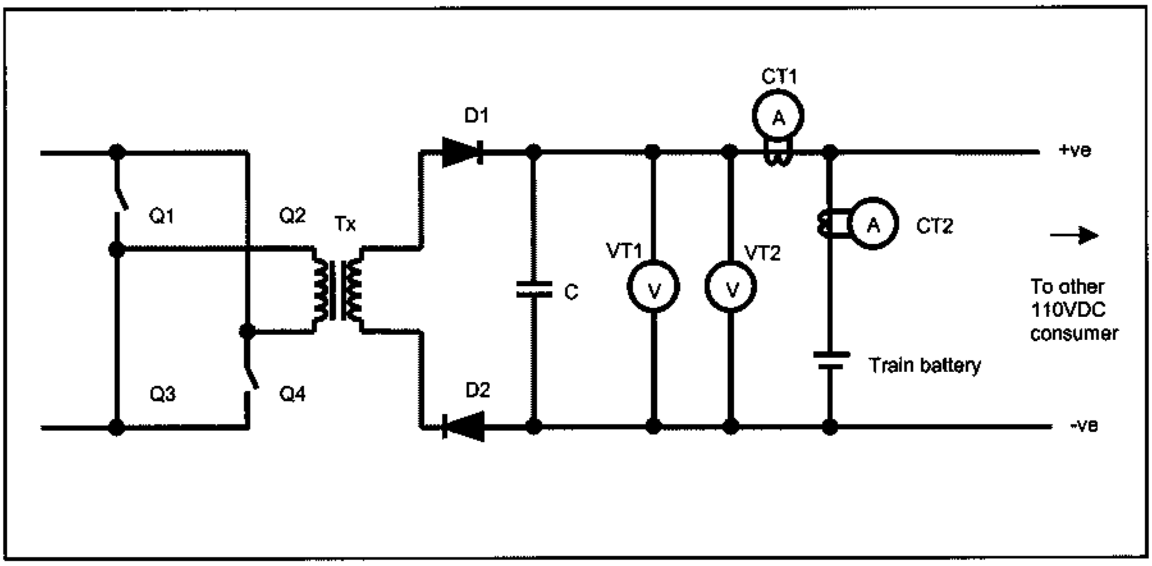


Figure 4.14: BLG negative cycle looping

The BLG has galvanic separation meaning the DC Link is separated from BLG output using the step-down transformer. Therefore, it protects DC Link in case 110V DC load had short circuit.

4.1.5 Train Batteries

Train Batteries is an external block, which connected directly to BLG consist of 9 units 12VDC free maintenance automotive / industrial battery. During Battery Direct (BD) or Battery Normal (BN) operation, APC used the power from these batteries to power up train instrument. During Battery Clean (BC) operation, BLG recharge the batteries.

A good battery should have low impedance (internal resistance) while the providing high current. This can be measured using Battery Analyzer. The total voltage of a set of batteries is ranging from 80VDC to 120VDC.

4.1.6 DC Link and Capacitor Banks

DC link is a zinc plated copper steel located underneath all modules. This component is used to transfer 670V DC from 4QC to PWMI and BLG. As safety, please attach earthing device onto Earthing Spheres (item 4.2.9) before touching the DC link.

Capacitor banks that located inside D1, J1 and G1 modules are used to regulate ripple 4QC DC voltage. It is also used to store-release power in case PWMI or BLG loads fluctuated.

4.2 Filter and Protection Devices

The purpose of filter and protection devices is to avoid severe damages on APC components during failure occurrence and also to improve the APC performance.

4.2.1 Fuses and Circuit Breakers

Fuses and Circuit Breaker was used to protect electrical and electronic component from over current. Any blown fuse (except 400A for 350V AC input voltage) and tripped breaker is reported to the APC main controller, the M1300.

4.2.2 Main Contactor

The Main Contactor (A1-K1) purpose is to connect or isolate the 350V AC input voltage from Main Transformer. It was controlled by M1300 in negative switching mode.

Main Contactor is equipped with a power saving board underneath to avoid the main contactor consuming unnecessary current to hold it close state. Details on the power saving board explained in Attachment 1.

4.2.3 Precharging Contactor and Resistor

The Precharging Contactor (A1-K2) purpose is to bypass Main Contactor and connect the input voltage to a series of pre-charge resistors (A2-R1, A2-R2 and A2-R3). Precharging the system before full operation is vital to protect the power electronic component such IGBT, diode and capacitors from short circuit.

During precharging state, precharging contactor closed and only small voltage is supplied to charging the DC link capacitors. This is done by input voltage reduction using precharging resistors. Only module G1 of the 4QC is powered up during this process.

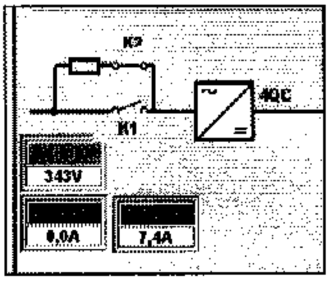


Figure 4.15: APC precharging state

4.2.4 Sine Filter Reactor and Capacitor

Sine Filter Reactor (-L2) is used to smooth out the sine current from PWMI. The basic operation is to store-release AC current. Any failure on this component will cause low or over current.

Sine Filter Capacitor (A1-C1 to A1-C6) is used to smooth out the sine voltage from PWMI. The basic operation is to store-release AC voltage. Any failure on this component will cause low or over voltage.

4.2.5 Main Ventilator Block

This block comprises a 3-phase motor (-M1), three contactors (A1-K3, A1-K4 and A1-K5) and two circuit breakers (A1-Q12 and A1-Q13). The purpose of this block is to cool down the heat sink temperature of all modules. If it detects any high temperature reading (more than 45°C), it will turn into high-speed mode for rapid cooling. This block was controlled by M9000 (item 4.4.4).

The 3-phase motor fan used in this block is called as dallandar motor. It can be switched to high or low speed by changing its wiring configuration. This motor comprises two winding on each phase.

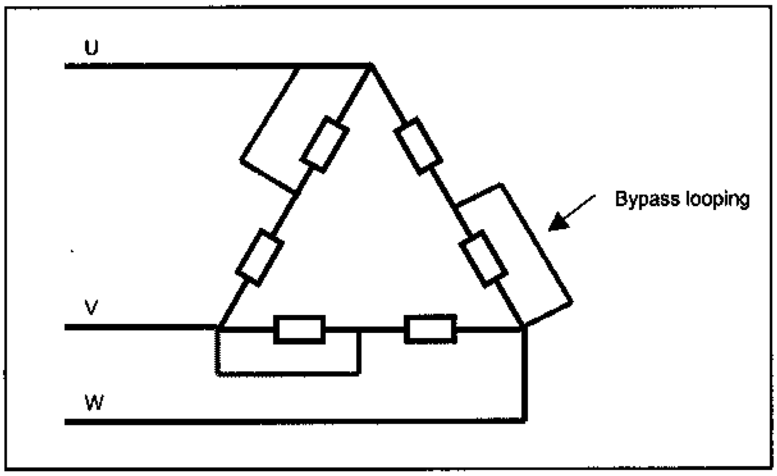


Figure 4.16: Motor fan low speed connection

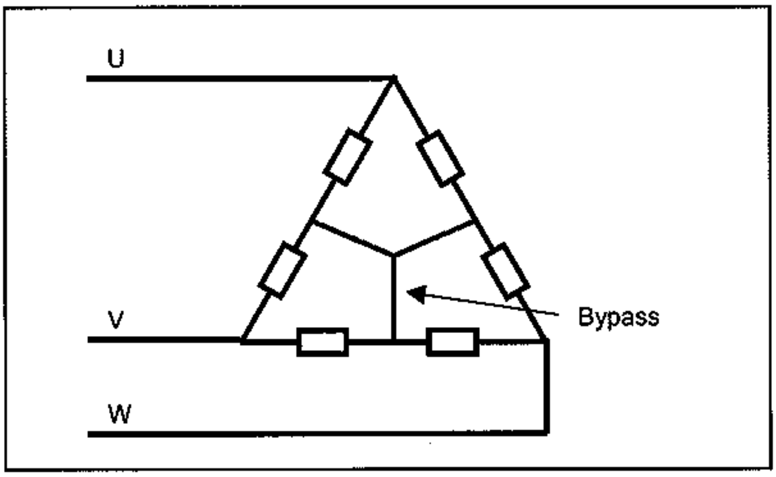


Figure 4.17: Motor fan high speed connection

According to drawing on page 6 in APC wiring diagram, R00 RSE 92110 YS 0001 B, K5 is used to supply 3-phase power into the motor. Another two contactors, K3 and K4 are used to manipulate the wiring configuration by bypassing some coils in the motor. During low speed, K4 closed while K3 remain opened, it is vice versa for high speed (shown on figure 4.16 and 4.17). This creates the high or low speed of the motor fan.

4.2.6 Output Contactor

Output contactor (A1-K13) is used to connect or disconnect the APC 3-phase output from rest of the consumer network. It was controlled by M1300 and only close after 3-phase voltage is made available by the PWMI.

In case the APC failed, this contactor opened and train enter the redundancy mode.

4.2.7 EMC Filter

EMC filter (A1-A1) purpose is to filter any harmonic distortion that exists in 3-phase voltages. This is crucial to prevent overheating on PWMI modules and loads.

4.2.8 DC Main Contactor

DC Main Contactor (A1-K12) is used to connect the train battery to all DC loads upon train battery ON. This is also to start-up the APC control system. This contactor is control externally by the battery ON button in the Driver cab.

4.2.9 Earthing Sphere

Earthing Sphere (E1, E2 and E3) is used as earthing point to discharge the DC Link residual voltage that exist in capacitor bank before commencing any maintenance work on the APC.

4.3 Monitoring Devices

The purpose of monitoring devices is to monitor and provide feedback on APC operation. It was connected directly to M2000 boards for better real time monitoring. This combination is the primary protection of APC component by shutting down the operation in case of failure occurrence.

4.3.1 Input Voltage Detection (-U2)

The Input Voltage Detection is used to detect the input voltage. Main Contactor (A1-K1) and Precharging Contactor (A1-K2) only enable after this unit sense the input voltage.

The input voltage was measured from a voltage transformer nearby pantograph unit and only available after the train pantograph is up (OCL voltage exist). This device was connected directly to 4QC for real time measurement.

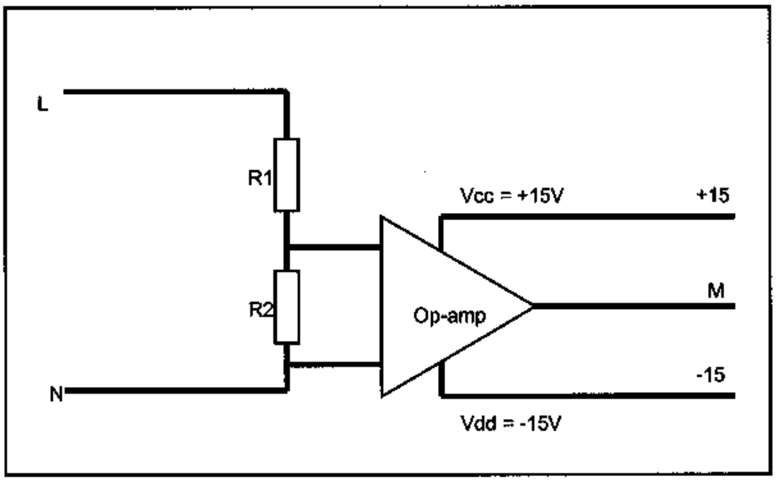


Figure 4.18: Input Voltage Detection

The transducer uses operational amplifier (op-amp) concept. Voltage divider resistors (R1 and R2) are used to reduce the voltage into readable value by the Op-amp. It then amplified by the Op-amp within range of +15V to –15V. The amplified signal is then transmitted via M (measure) wire to M2000 that attached to 4QC for analog-to-digital conversion.

In case the 150V AC wiring connection is wrongly connected, there is possibility that the 4QC operates in reverse direction thus damaging that module.

4.3.2 Earth Detection (A1-A2)

The Earth Detection is used to measure earth leakage voltages on load or wiring of the train. This transducer also uses same concept of Op-amp, which explained in item 4.3.1.

This unit was connected to M1300. By detecting a fluctuated reading, it determines that the measured value came from AC earth fault or a DC earth fault if linear value received.

4.3.3 AC Voltage Measurement (-A3)

The AC Voltage Measurement is used to measure 3-phase output voltage from PWMI. Output Contactor only enable if this unit measure 400V AC exist on its measuring scope.

This transducer also uses same concept of Op-amp, which explained in item 4.3.1. It just acts as monitoring unit since PWMI also measure its output voltage value from an internal transducer. It was connected directly to PWMI for real time measurement.

4.3.4 Battery Temperature Sensor

Battery Temperature Sensor is used to measure the train batteries temperature. It was a NTC (Negative Thermal Coefficient) type sensor therefore an increase of temperature would decrease the resistance value of the sensor.

This sensor was directly connected to BLG for monitoring purposes. The nominal value of this unit is 8kΩ. An increase of temperature beyond 45°C will reduce the charging current from BLG to minimize further increment of temperature. This is vital to avoid the electrolyte inside the battery dried up thus damaging that battery.

4.4 Control and Communication

4.4.1 M1300 (Controller Master)

The M1300 is the master controller of APC unit but it doesn't gain control of the modules. This unit is equipped with binary input and output port which control and monitor contactors and breakers. These I/O statuses can be checked via LEDs and in SIBMON software. Further details are described in Description Sibcos M1300, Doc. No. R00 RSE 92110 YR 0002 A Sibcos M1300.

The M1300 communicates with other modules and M9000 via CANBus. In case of internal fault, the faulty module will send a fault message to M1300 and shut down itself. Upon receiving the message, the M1300 then opened appropriate contactors to isolate the problem.

The M1300 also communicates to train CCU via MVB lines. It is to report failure and certain voltage reading to CCU for collaboration controls. For example, if an APC malfunction, M1300 send fault message to CCU and then the CCU will trigger 400V AC Busbar and restricted passenger air conditioning.

4.4.2 M2000

The M2000 is a controller board, which mounted on D1, J1 and BLG. Although it is the same board, it must be loaded with appropriate software. Loading the module software is described in item 5.2.4.

This board acts as primary controller to the modules. It detects and decides either to shut down the module in event of a failure. It also monitors the heat sink temperature and DC Link voltage.

During internal faulty, for example "PWMI VCE short circuit", the M2000 on PWMI J1 module will stop that module operation and transmit a fault message to M1300, the M1300 then opened up Output Contactor (A1-K13). The M2000 is then try to restart the module if possible. 4QC and BLG operation is not disturbed in this way.

In the event of external fault, M1300 will send an OFF command to all modules and the modules shut down on its will.

4.4.3 Driver Board

Driver Board is attached to all modules and act as the module operator. It received the signal from M2000 and runs the IGBTs. As safety features, it has galvanic separation to isolate high voltage on the driver board from M2000.

4.4.4 M9000

The M9000 act as I/O port extension of M1300 and it was used as thermal management unit. It controls the Main Ventilator block (item 4.2.5).

This unit reads all module heat sink temperature via CANBus and turns the motor fan into high speed if there is any reading reach 45°C and above. Further details regarding this controller is described in R00 RSE 92110 YR 0003 A Sibcos M9000.

4.4.5 MVB Communication

MVB Communication is used by the M1300 to communicate with train CCU to report its status and certain voltage and current reading.

4.4.6 Hardwire Controls

Hardwire Control is used for external control and circuit looping purposes. APC Battery ON, APC main contactor ON, emergency OFF and several more controls were triggered through this method.

4.4.7 CANBus Communication

CANBus communication is used as internal communication between M1300, M2000 and M9000 for control and monitoring purposes. This is serial loop circuit, therefore any breakage will cut-off the communication thus shutting down the APC.

5 Utility Software

Utility software is the program, which provided by APC manufacturer to assist user in monitoring and troubleshooting tasks. It comprise of:

- SIBMON
- HistoryViewer
- SBLoader

5.1 Software Installation

The installation file named "setup.exe" can be accessed the in the service PC hard drives, located in "C:\Desiro ET425 Softwares.......\To be installed\APC SOFTWARE\Sibmon" or from installation CD kept by RST superior. Simply double click that setup file and follow further requested instruction.

5.2 SIBMON

SIBMON is used to read M1300 and M2000 stored and real time variables for monitoring and diagnostic APC condition. It is Man-Machine Interface (MMI) software where user can check the APC variables. This software will assist the user by providing important data and notification in event of failure occurrences. Detailed description on all function of SIBMON is described in R00 RSE 92110 YR 0001 A SIBMON.

Note: Variables means data or value that the user can read and interpret from SIBMON.

5.2.1 Starting the SIBMON

This software required RS232 communication link between Service PC COM port to controller (M1300 or M2000) board. It will automatically start the appropriate project when RS232 communication established.

In case that there was no communication, the software will start up the offline mode. Refer item 5.2.6 for starting SIBMON in offline mode.

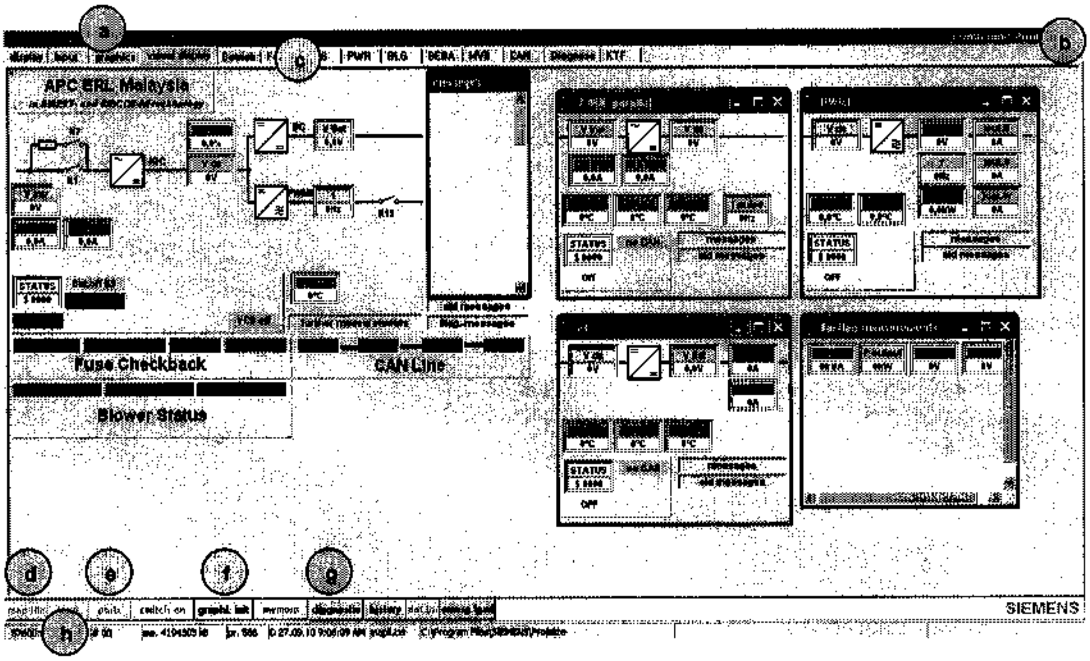


Figure 5.1: SIBMON overview for M1300 (Master project)

a. Title Bar - This function indicates the software version of connected controller.

b. Communication status - This function indicates the communication status between service PC and controller.

c. Tab Buttons - These are the list of variables which been stored by that controller.

d. Map File - This function initializes the communication between SIBMON and controller. It was executed automatically upon RS232 communication established.

e. Ports - This function is to set the COM port and its baudrate for RS232 communication.

f. Graphi. Init - This function is used for Graphic Function tab. Refer item 5.2.3 for details.

g. Diagnostic, Memory and History - This function is used for downloading the recorded fault message. Refer item 5.2.5 for details.

h. load - Uploading firmware into controller. Refer item 5.2.4

5.2.2 Visual Display

The Visual Display shows summary of all variables available on a particular controller. It indicate different display when certain project is loaded or when the service PC connected to:

1) **APC side COM port or at M1300 (Master project SIBMON)**. This displays all variables available on M1300 (Refer Figure 5.1 for image). It shows:

   a. Status of contactors - Illustrated contactor status of A1K1, A1K2 and A1K13

   b. Status of fuses - Monitoring check-back signal of fuses (except input 400A fuses)

   c. Voltage reading - Measured voltage values by modules. Double click on module icon to open detailed measurement.

   d. Current reading - Measured current values by modules. Double click on module icon to open detailed measurement.

   e. M1300 status - This indicates which step of that controller is currently in. Refer item 6.2.5 for details.

   f. Further Measurement - This indicates the calculated value of Earth fault and capacity usage.

   g. CAN Line - This indicates the status of CANBus network.

   h. Old Message and Diag. Message - This indicates the fault message.

2) **M2000 on the 4QC (Module project SIBMON)**. This displays all variables available on 4QC M2000. It shows:

   a. U Ein - Input voltage value measured from Input Voltage Detection

   b. I ein1 - Input current on module 4QC D1 (measured by a current transducer on the module)

   c. F Netz - Input frequency

   d. U aus - DC Link voltage (measured by the module via a transducer mounted on it)

e. S Gerät - DC Link power (calculated by the module based on measured current and voltages.

f. SIBCOS - M2000 controller board temperature. Measured by a temperature sensor mounted on the board. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

g. KK-Bst.D - Module D1 heat sink temperature. Measured by a temperature sensor mounted on the heat sink. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

h. Status - Status that the controller is currently in. Refer item item 6.2.5 for further details.

i. Meldungen - This indicates the fault message.

j. SPS-Zustand - This indicates the warning message.

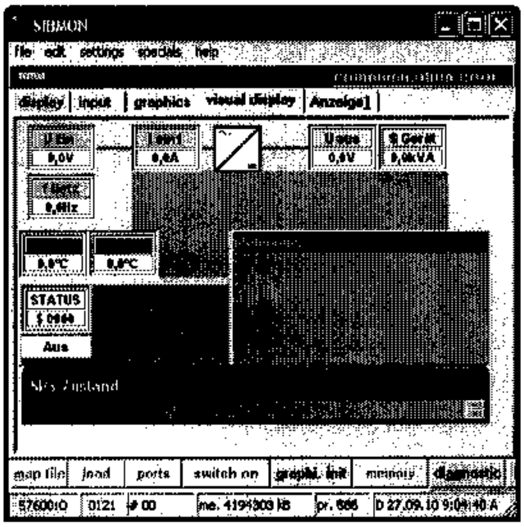


Figure 5.2: SIBMON overview for M2000 (4QS project)

3) **M2000 on the PWMI (Module project SIBMON).** This displays all variables available on PWMI M2000. It shows:

a. Ud[V] - DC Link voltage (measured by the module via a transducer mounted on it).

b. –I(U) and I(V) - Output current (measured by a pair of current transducer mounted on PWMI G1 module)

c. *I(W)* - Output current (calculated by M2000 based on measured V and W phase current)

d. Uaus (Soll) - "Should be" output voltage. Nominal value is 400V (RMS). This is a calculated value based on the IGBT pulsing frequency.

e. Uaus - Actual output voltage (measured by output voltage detector)

f. F (PWR) - Output frequency. Nominal value is 50Hz (note: Output frequency is different from IGBT pulsing frequency)

g. F (Puls) Hz - IGBT pulsing frequency. This is a calculated value by M2000 for IGBT triggering signal to produce 3-phase sine wave. Refer <u>item 4.1.3</u> for details.

h. T (KK) - Heat sink temperature on J1 module. Measured by a temperature sensor mounted on the heat sink. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

i. T (ZKK) - Heat sink temperature on G1 module. Measured by a temperature sensor mounted on the heat sink. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

j. M2000 - M2000 controller board temperature. Measured by a temperature sensor mounted on the board. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

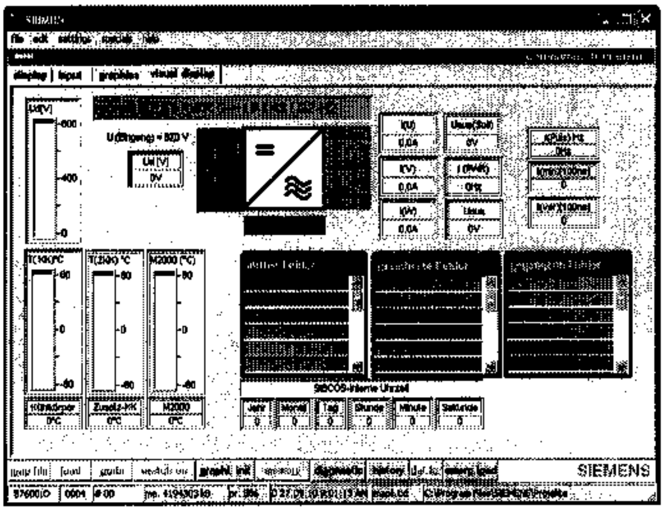


Figure 5.3: SIBMON overview for M2000 (PWMI project)

4) **M2000 of the BLG (Module project SIBMON).** This displays all variables available on 4QC M2000. It shows:

a. U in - DC Link voltage (measured by the module via a transducer mounted on it).

b. U Batt - BLG output voltage (only applicable on BC mode)

c. U Batt2 - Train Battery voltage (only applicable on BN mode)

d. I Device - Total BLG output current, including I Batt (Measured by a current transducer mounted on BLG module.

e. I Batt - Current from battery charging purposes (Measured by a current transducer mounted on BLG module.

f. SIBCOS - M2000 controller board temperature. Measured by a temperature sensor mounted on the board. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

g. Heats. - Heat sink temperature on BLG module. Measured by a temperature sensor mounted on the heat sink. In form of a cable lug with a blue paste. Nominal value is 8kΩ.

h. Battery - Refer item 4.3.4 for details

i. Meldungen - This indicates the fault message.

j. SPS-Zustand - This indicates the warning message.

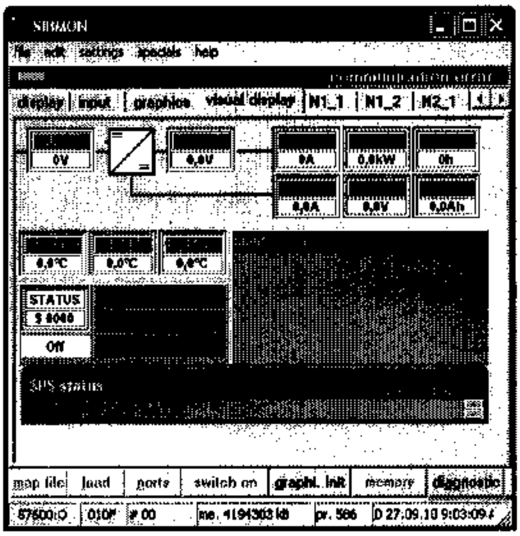


Figure 5.4: SIBMON overview for M2000 (BLG project)

5.2.3 Graphics Function

Graphics Function is used to display the module input and output value in graph form in real time. This function can be called by selecting "*graphics*" on the tab buttons on upper left of the SIBMON. This was also described in R00 RSE 92110 YR 0001 A SIBMON.

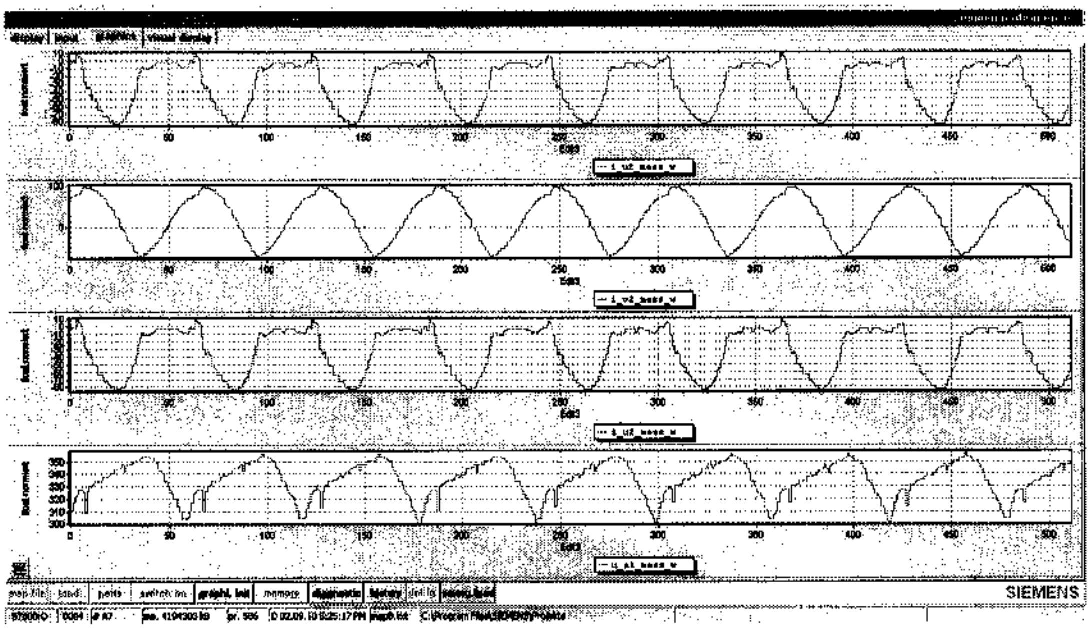


Figure 5.5: Set of graphs in Graphics function

This graph indicates a captured time frame, meaning it display a recorded values in a period of time and then draw it in form of graph that the user saw. To update this graph, click a button located at lower left of the screen (above "map file" button).

This graph can be combined or separated for easy viewing. To do this, click "*graphi.init*" and then select "*coordinate systems*".

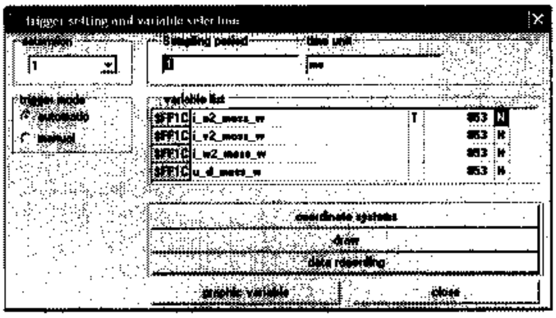


Figure 5.6: Graphi. Init pop-up window

Another ("*trigger setting and variable selection*") display will pop-up. There are 4 set of graph ("*coordinate system 1 to 4*") can be set from here. To add several lines in a single graph, simply add the variables from the list in one of the coordinate system. To hide the graph, unchecked the "*visible*".

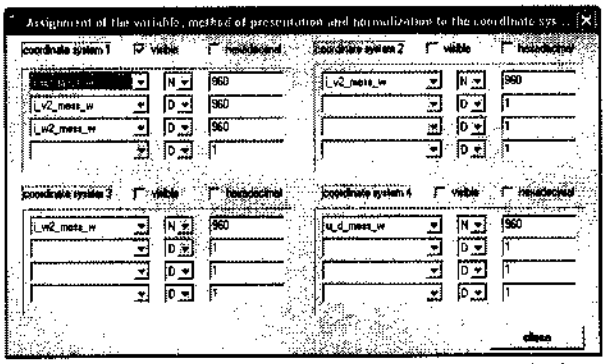


Figure 5.7: Coordinate systems pop-up window

To add more variables, click the "*graphi. Init*" and then the "*graphic variable*". Click the appropriate address on that "*variable list*" table and drag it to previous "*variable list*" on "*trigger setting and variable selection*". For normal voltage and current reading, set the scaling (Normierung) to 960 and the format (Dst.) to "N" (Float Number Scaled).

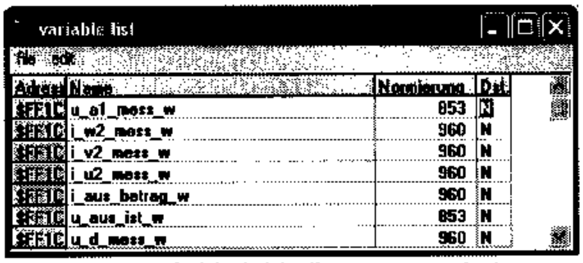


Figure 5.8: Variable list pop-up window

These are the meaning of variable list for graphic init:

1) 4QC
   - i_4qs_10_messwert_w = Current Modul G1
   - i_4qs_11_messwert_w = Current Modul G1
   - i_4qs_20_messwert_w = Current Modul G2
   - i_4qs_21_messwert_w = Current Modul G2
   - u_e_messwert_w = Line voltage
   - u_d_messwert_w = DC link voltage

2) PWMI
   - i_u2_mess_w = Current L1
   - i_v2_mess_w = Current L2
   - i_w2_mess_w = Current L3 (Calculated Value)
   - u_a1_mess_w = Output Voltage 3AC RMS
   - u_d_messwert_w = DC link voltage

3) BLG
   - u_b_messwert_w = Battery voltage
   - I_g_messwert_w = Battery charging current
   - I_b_messwert_w = BLG output current (total charging and consumer current)
   - U_d_messwert_w = Dc link voltage

5.2.4 Firmware Uploading

Firmware uploading is used to upload project software into a controller, either M1300 or M2000. This is required when installing new controller to operational APC or if there is update on project software version. Certain function on SIBMON and HistoryViewer are disabled if old controller firmware version is used. This was also described in R00 RSE 92110 YR 0001 A SIBMON.

To load the software, click the "load" button on the lower left of the SIBMON and search for the project file, which located at *"C:\Desiro ET425 Software...\To be installed\APC SOFTWARE\Software"*.

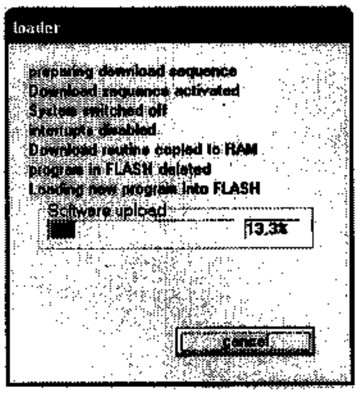


Figure 5.9: SIBMON firmware uploading

If the software cannot be downloaded or interrupted during installation or empty controller (new controller), please use SB-Loader software for uploading.

There is a component code, a hardwire jumper that mounted on each controller and has its own configuration, is used to double-check the loaded program. The controller will refer to these jumpers and if there is mistake, eg. 4QC project into PWMI module, the controller will stop its operation.

Note: Installing Master Firmware into M1300 will also install other modules firmware.

5.2.5 Diagnostic, Memory and History Downloading

Diagnostic, Memory and History Downloading is used to readout the failure message from the controller. The readout indicates all necessary information used to assist in faultfinding task. This function only retrieves the data into a hexadecimal form, which requires HistoryViewer software to be interpreted. Refer item 5.3 for details.

Diagnostic Downloading is a superseded function, which only display summary of failure occurrence in chronological order. Please use Memory or History downloading to retrieve the failure occurrence readout.

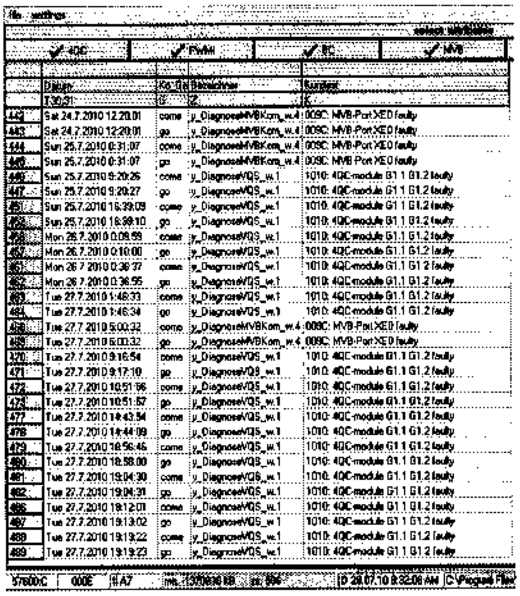


Figure 5.10: Diagnostic summary

History Downloading is commonly used since it was straightforward. Simply click "*History*" button on the lower left of the SIBMON and click "*name of file*" to create a readout file and then click "*load*". Memory address and memory length is fixed. The loaded readout is saved in "*.bin*" format.

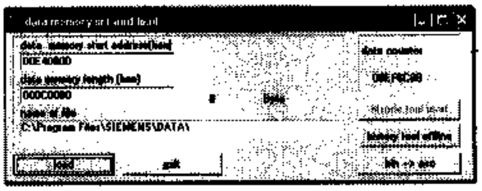


Figure 5.11: History download pop-up window

Memory Downloading is similar to History Downloading but it was for advance purposes where user can readout any parameter available in the controller. Click on "*Memory*" on the lower left of the SIBMON and key in the "start address" and "number of bytes". Then, press "load" button to began downloading. The loaded readout is saved in "*.dat*" format.

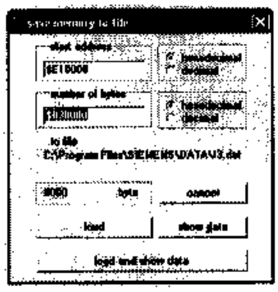


Figure 5.12: Memory download pop-up window

5.2.6 OFF-Line Mode

OFF-Line mode is another SIBMON program start-up function where the service PC is not connected to the controller or if it had communication error.

After the program called, a pop-up window "*select workstation*" appeared, click "*workstation 1*".

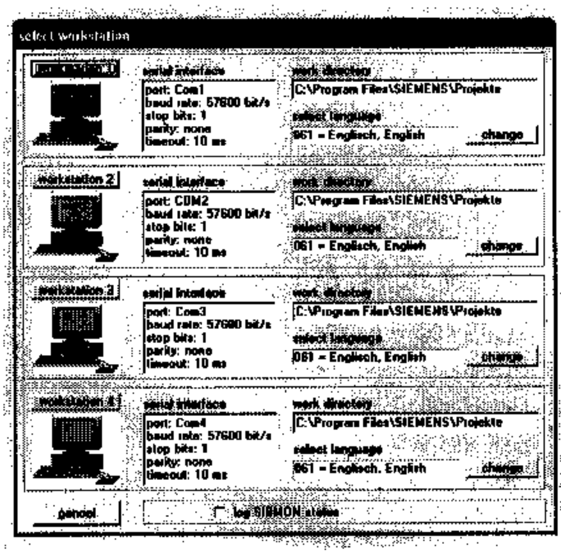


Figure 5.13: Workstation selection pop-up window

It then informing the user that "*SIBMON error*", click "*Yes*" to continue. Key-in "*249800*" in the right column as password and press enter. Then select *"000E: Master Malaysia*" and any mapfile to enter SIBMON offline mode.

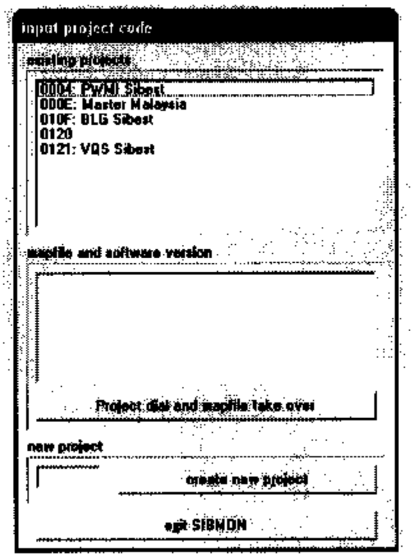


Figure 5.14: Project selection pop-up window

5.2.7 SIBMON Help

SIBMON Help it the quick reference to all information regarding the SIBMON software. User can use this function to interpret the fault message meaning. It has the information on possible cause, further information and etc to ease the faultfinding task. This function is only available on Master Project.

5.2.8 SIBMON Special Function

The SIBMON also provide some advance monitoring features, which placed under Special Function, which must be unlocked. To enable it, connect the service PC to controller and run the SIBMON. Then, select "*special>password*" at menu bar and key in "*249800*" as password.

1) Gray Text Button
   This is located at lower left of the SIBMON and a sometime disable upon loading. Tools such Memory and History downloading are special function.

2) Resizing the SIBMON display
   This is required when there were missing pop-up item such further measurement and etc. Select "*setting>visual display*", then key in "*2000*" on both vertical and horizontal column.

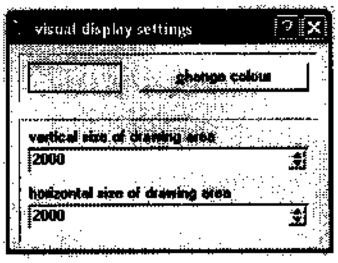


Figure 5.15: Resizing option pop-up window

3) Advanced Real Time Variables
   This is the detail measurement which can accessed under special function. It can be selected on tabs list at top of the SIBMON.

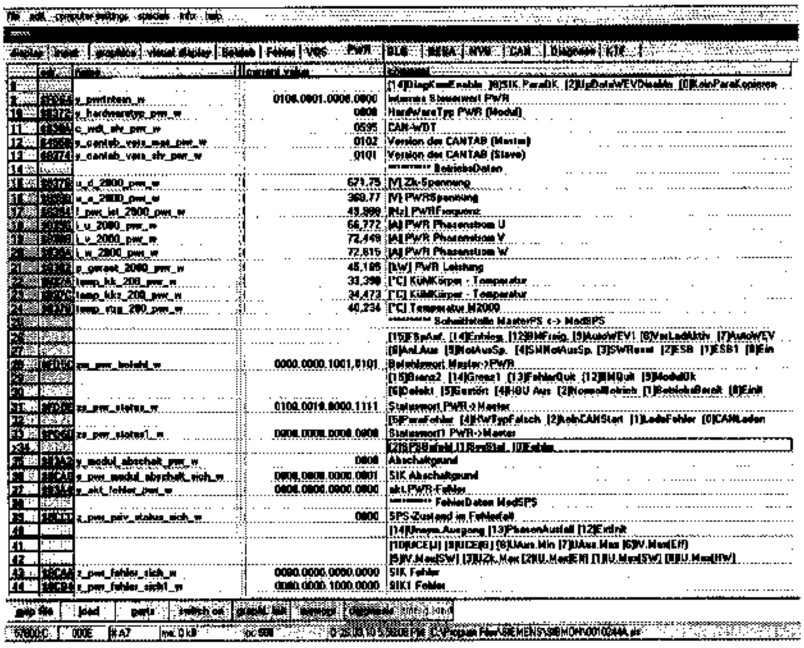


Figure 5.16: Advance real time variable table

5.3 HistoryViewer

HistoryViewer is used to interpret downloaded readout made by Memory or History Downloading (item 5.2.5). This software requires some manual setting by the user to run properly. Incorrect setting could cause an error later on.

5.3.1 Opening Readout

To open the saved readout, simply call HistoryViewer program and key-in "*249800*" as password. Select "*File>Open>Open Project*" on the upper left of the HistoryViewer.

On the "*Open*" pop-up window, go to "*C:\Program Files\SIEMENS\Projekte\FSP*" and then select the appropriate project file "*.FPR*".

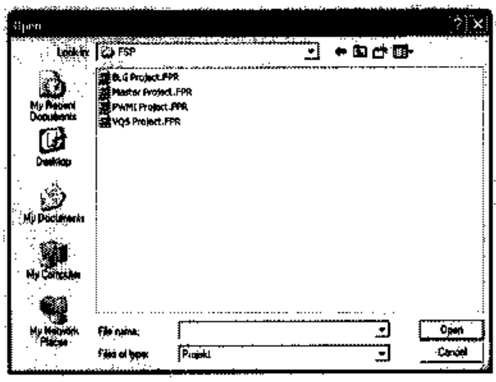


Figure 5.17: FPR project file pop-up window

Then select "*File>Open>Open Data Table*" and select the downloaded readout. The readout is now ready to be analyzed. Refer to item 6.2.3 for details on analyzing the readout.

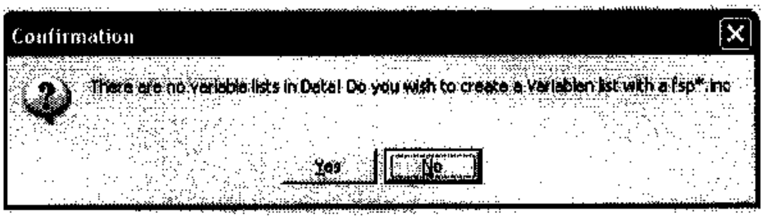


Figure 5.18: Variable list comfirmation pop-up window

If a "*Confirmation*" pop-up window appear, click "*Yes*" and then go to "*C:\Program Files\SIEMENS\Projekte\FSP*" and select the appropriate file. Opened Project file and opened variable table must be the same, wrong selection will causing improper interpretation from the program.

The segment between "*Environment Data*" and fault message table can be resize. Simply move the cursor between them and wait until the cursor changes into up-down arrow. Click and drag as needed.

Note: Impropriate firmware version of the controller during memory or history downloading might causing readout cannot be opened by the HistoryViewer.

5.3.2 Navigating the HistoryViewer

To get the fault message details, simply double click the colored circle on the left side of the fault message table. The loaded readout will indicate these important functions, which are:

4) Fault
This is the fault word during failure occurrence. It was indicated in binary form and each binary has its own meaning. Click "Remark" column and move the cursor to any row in "*Value*" column. A list will appear indicating the meaning of each bit.

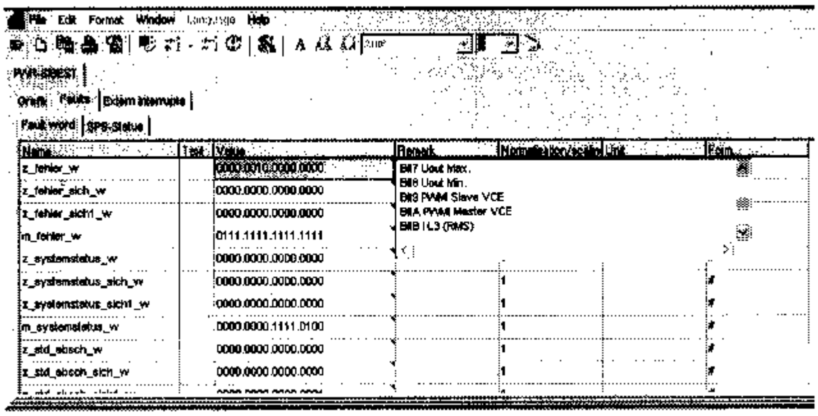


Figure 5.19: Fault word variables table

There are several names, which are almost the same, having an additional text "*_sich_w*". This indicated the chain event of an occurrence. For example:

- *z_fehler_w* = current fault word
- *z_fehler_sich_w* = previous fault word
- *z_fehler_sich1_w* = old fault word

5) Graphic
This is the module input or output value in form of graph and the purpose is similar to Graphics function (item 5.2.3) but this is stored value at the moment of an occurrence. The time scale for this graph is in millisecond. Take note that the information in this graph sometime is not accurate.

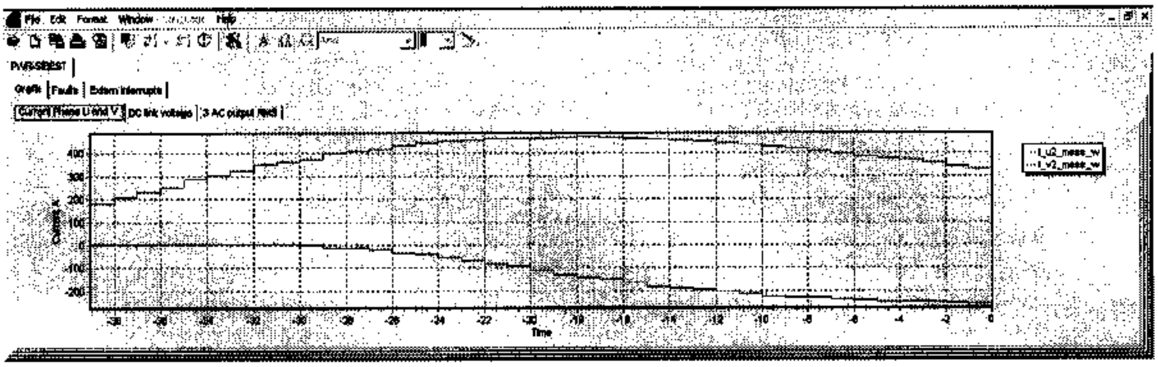


Figure 5.20: Graphical function of HistoryViewer

6) lfd. Number
It is the number of sequence in which it was stored inside the controller memory. The controller stored these memory in cyclic arrangement (similar to BCU readout) therefore the sorting is sometime mixed up. It is important that the user use lfd. Number to sort the fault message. Sorting by date makes the table grouped into name of day. The color of the circle has its own meaning, green is for latest memory, while yellow and red are the older record.

lfd. Number	History texts	Date	Time	No. of rows	Offset	Rom Address	SW-Version	Number of History columns
Z 61	VCE_PWMI Slave	Thu 29/10/2009	11:06:45	40	13	0E3F6D0H	BCD2WC20.03A	6
Z 34	VCE_PWMI Master	Wed 25/5/2005	12:01:47	40	12	0E3800EH	C6H0WC20.03B	6
Z 36	VCE_PWMI Master	Wed 25/5/2005	12:02:34	40	26	0E388DAH	C6H0WC20.03B	6
Z 27	Current Max fast Phase U or V	Thu 2/9/2010	17:02:28	40	7	0E17AC4H	BCD2WC20.03A	6
Z 29	Current Max slow Phase W	Thu 2/9/2010	17:02:28	40	11	0E18390H	BCD2WC20.03A	6
Z 22	Watchdog	Mon 2/11/2009	16:00:43	40	0	0E164C6H	BCD2WC20.03A	6
Z 23	Watchdog	Mon 2/11/2009	16:00:43	40	0	0E1692CH	BCD2WC20.03A	6
Z 24	Watchdog	Mon 2/11/2009	16:00:43	40	0	0E16D92H	BCD2WC20.03A	6
Z 28	Cunnet Max slow Phase V	Thu 2/9/2010	17:02:28	40	10	0E17F2AH	BCD2WC20.03A	6
Z 30	PWMI I L1 (HW)	Thu 2/9/2010	17:07:48	40	9	0E187F6H	BCD2WC20.03A	6
Z 31	PWMI I L3 (SW)	Thu 2/9/2010	17:08:14	40	16	0E18C5CH	BCD2WC20.03A	6
Z 2	PWMI Uout Min.	Thu 29/10/2009	15:06:39	40	27	0E10CCEH	BCD2WC20.03A	6
Z 3	PWMI Uout Min.	Thu 29/10/2009	15:52:12	40	27	0E11134H	BCD2WC20.03A	6
Z 4	PWMI Uout Min.	Thu 29/10/2009	16:28:51	40	7	0E1159AH	BCD2WC20.03A	6
Z 5	PWMI Uout Min.	Fri 30/10/2009	14:38:17	40	5	0E11A00H	BCD2WC20.03A	6
Z 6	PWMI Uout Min.	Sun 1/11/2009	10:08:30	40	35	0E11E66H	BCD2WC20.03A	6
Z 7	PWMI Uout Min.	Sun 1/11/2009	10:17:22	40	14	0E122CCH	BCD2WC20.03A	6
Z 8	PWMI Uout Min.	Sun 1/11/2009	10:20:23	40	29	0E12732H	BCD2WC20.03A	6

Figure 5.21: lfd. column

7) History Basis
This is the name of fault message. Please refer to SIBMON Help (item 5.2.7) for the fault message description.

5.4 SIBCOS Loader

SB Loader is used to upload firmware into M1300 or M2000 controller. It is similar to Firmware Uploading by SIBMON (item 5.2.4).

Before uploading process began, shut down the controller (better to shut down the APC for safety) and connect the service PC to controller using RS232 cable. Close other utility software such SIBMON because the COM port cannot be shared. Plug in a jumper to the controller board and then power up that controller again.

Call the SIBCOS Loader from *"Start>All Program>SIEMENS-Tools>SIBCOS LOADER"*. Then double click the *"program- file(*.h86)"* and select the appropriate file from *"C:\Desiro ET425 Software…\To be installed\APC SOFTWARE\Software"*.

On "*Select Controller*" area, select "*1;Load Software*" then click "*start*" button on the upper right of the SIBCOS-Loader. Wait until the uploading finishes.

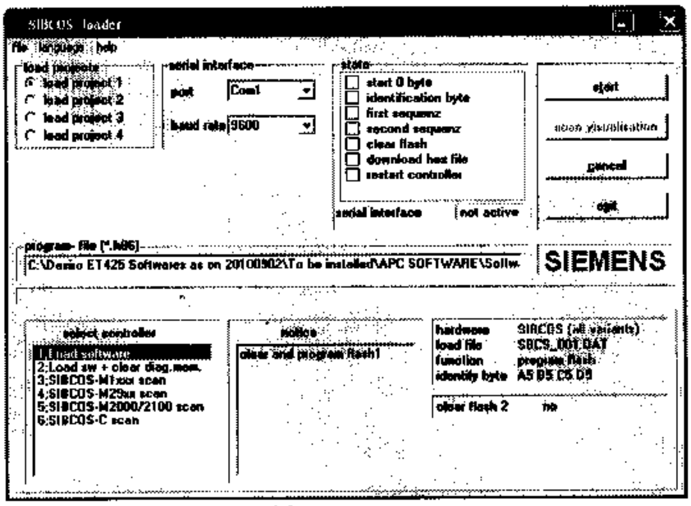


Figure 5.22: SB Loader options

Once the uploading process finished, remove the jumper and that controller is now ready for its normal operation. This instruction is also available in SIBCOS Loader Help function.

6 APC Troubleshooting

6.1 Common APC Failures

6.1.1 Short Circuits and Wiring Breakage

Short circuit and wiring breakage is very common on all components that conduct electricity. The symptom is that there was no voltage to power up consumers and loads.

Short circuit happened when a positive terminal (or L line in AC) is connected to negative terminal (or N Line in AC) without any load in between. This will create a power supply bypass where all current is concentrated at that point. Therefore, there will be no sufficient voltage on load but current surged on the supply point. This type of problem will cause all load depending on a single supply to switch OFF due to no power.

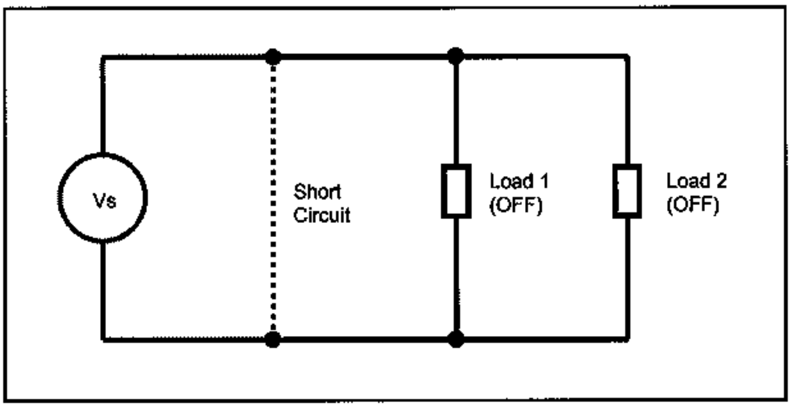


Figure 6.1: Short circuit diagram

Wiring Breakage happened when the circuit looping is not complete due to the electrical conductor were cut-off or disconnected. This creates a breakage thus no power were delivered to a portion or all loads depending on the single source. This type of failure commonly caused by wire snapped or detached.

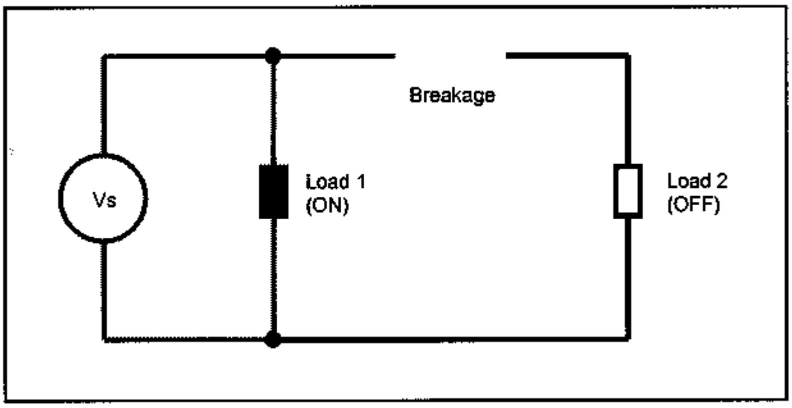


Figure 6.2: Wiring breakage diagram

6.1.2 Earth Faults

Earth Fault happened when supply voltage is shorted to ground (eg: train body). This is monitored by Earth Detection (item 4.3.2) and the value can be checked at "*Further Measurement*" on Master project SIBMON.

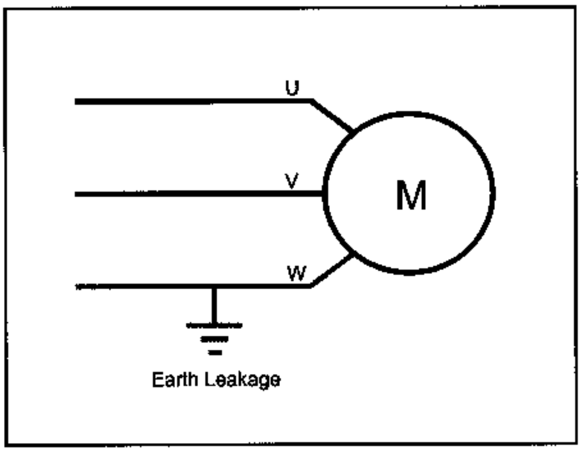


Figure 6.3: Earth fault diagram

This type of failure are usually occurred on high voltages section such modules, filters and loads. It was normally caused when electrical conductor were soaked in water or the wiring insulator torn and touched the ground.

6.1.3 Controller Faulty

Controller fault happened when the controller unable to executed its job and stuck somewhere in the control sequence due to internal (inside that controller) or external fault (other controller or signal fault). This type of failure commonly related to other failures such measurement error, communication error or contactor faulty.

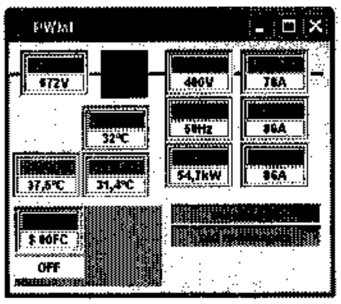


Figure 6.4: Fault STATUS message

6.1.4 Module Faulty

Module faulty happened when the module was unable to produce output due to its internal failure. Common failures are caused by communication error, M2000 defective or IGBT rupture. Some faulty doesn't interrupt other module operation. Utility software are often indicate module faulty or bolted for this type of failure.

- 4QC faulty / bolted – insufficient or no voltage on DC Link
- PWMI faulty / bolted – no 3-phase voltage or missing phase
- BLG faulty / bolted – no 110V DC voltage

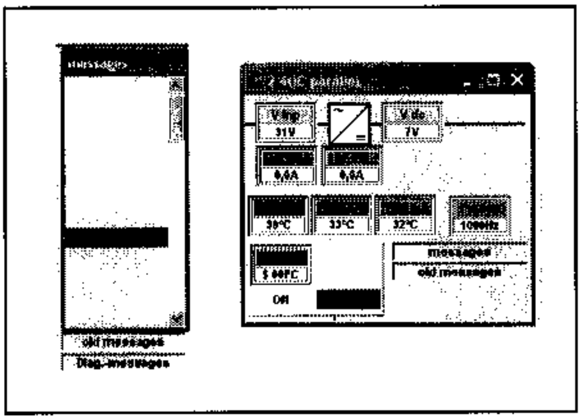


Figure 6.5: 4QC module faulty

Note: "*4QC disturbed*" message happened when the train VCB opened or during pantograph were lowered. This is not considered as failure message.

6.1.5 Measurement Error

Measurement error happened when the measured value differ from actual value. It was caused by defective controller or monitoring devices. This type of failures normally effecting other components because the controller cut-off the operation due to these false reading. It can be inspected by comparing the measured value indicated in SIBMON and measured value made by user using multimeter or clamp meter.

Note: It is important that the user to identified this problem at early stage of faultfinding.

6.1.6 Protection Faulty

Protection Faulty happened when protection devices disturbed normal operation of APC. This failure is categorize into two types, active and permanent protection faulty.

Active protection faulty will cause irregular voltage or current output. It might due to short circuit, wiring breakage or earth fault. It only happened during APC operational.

Permanent protection faulty caused by other failures such over current or over voltage on its protection area. This type of failure cuts off the circuit such blown fuse or tripped circuit breaker. This can be checked using continuity inspection and by checking the check-back signal on Master project SIBMON.

Figure 6.6: Blown fuse indication

6.1.7 Communication Faulty

Communication Faulty happened when the controllers cannot communicate with each other. This type of failure can only be detected using utility software. There are several causes of this failure that are:

- Controller cannot turn ON due to +110VDC is missing.
- Wrong firmware downloaded
- Wrong component code installed
- CANBus wiring breakage

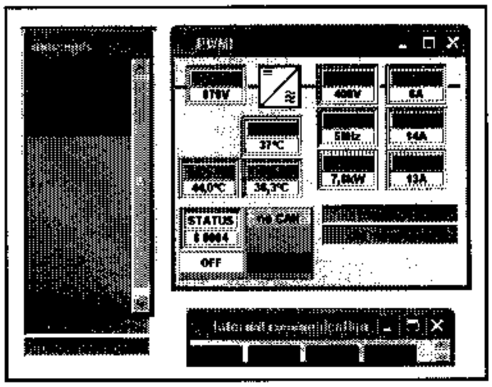


Figure 6.7: CANBus communication error

6.1.8 Contactor Failure

Contactor failure happened when the contactor unable to operate due to controller defect or wiring problems. The status of these contactors can be monitored by checking the contactor figures (K1, K2 and K13) in Master project SIBMON. It is also possible to observe the LED display located on M1300 or M9000 for these check back signal.

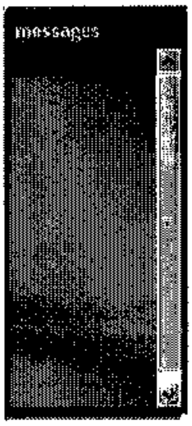


Figure 6.8: Contactor faulty message

6.1.9 Consumer and Load Problems

The consumer and load problems are external malfunction. There are two possible cause and effect on this type of failure. Insufficient or no power supply, this failure is originated from APC where it cannot deliver required power due to module defect and etc. Consumer or load defect, this failure is originated from the load itself where it drains too much power and usually interrupts APC operation.

The protection for these types of failure is the 3-phase motor circuit breaker inside 3S and 4S cabinets.

6.2 Utility Software Aid

Using the utility software is a compulsory during APC troubleshooting. By doing this, the user can check and monitor the APC conditions. The variables and fault messages are straightforward and this software alerts the user at the moment of a failure occurrence.

6.2.1 Reviewing the M1300

Reviewing the M1300 is the first step on fault finding process. The objective is to check APC status and condition at a glance. This way, the user can identify the failure section. Figure 6.9 illustrated the reviewing flow by operating the APC. It must be performed in sequence to ensure that the existing failure does not worsening the situation.

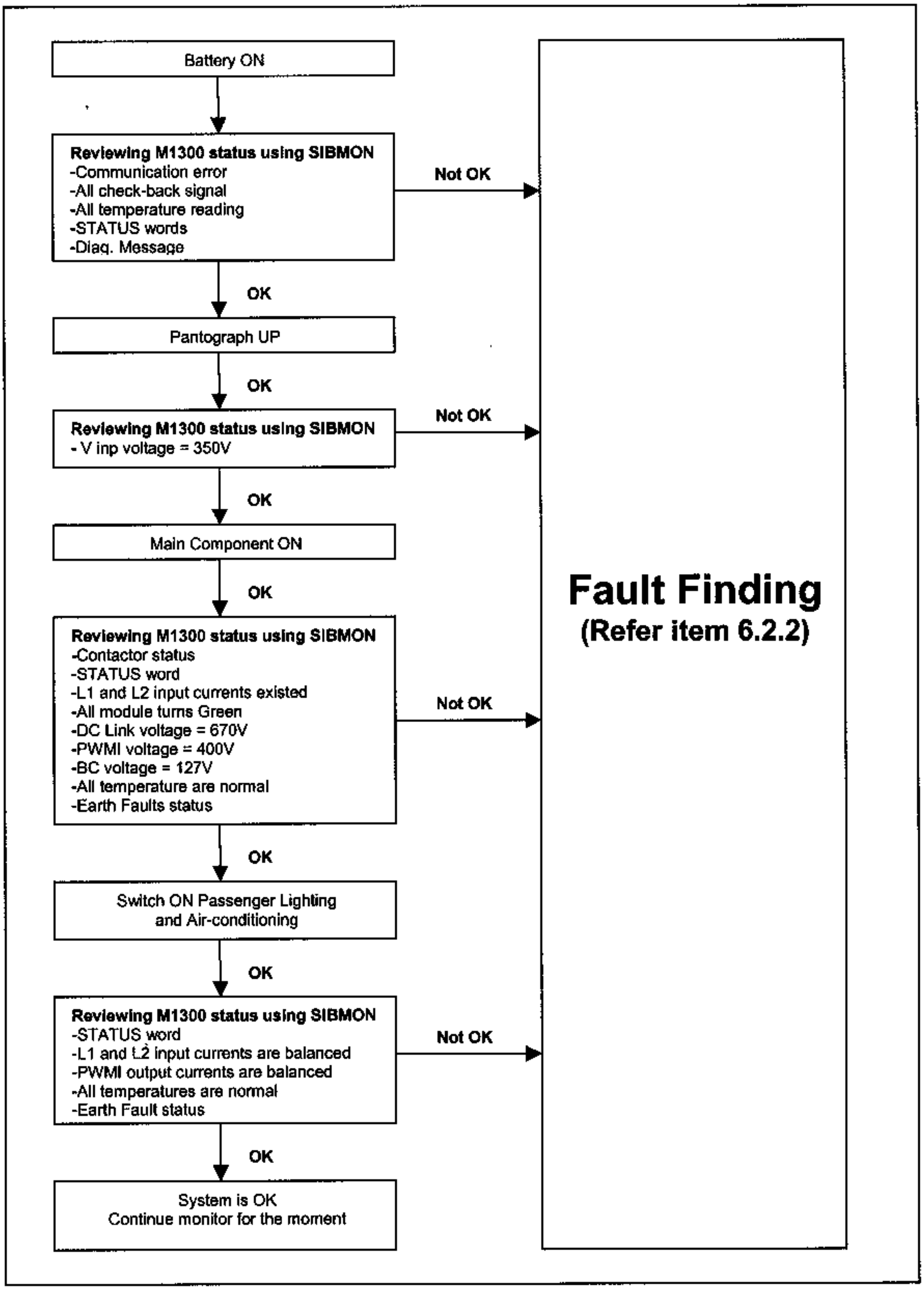


Figure 6.9: APC operation start-up sequence flowchart

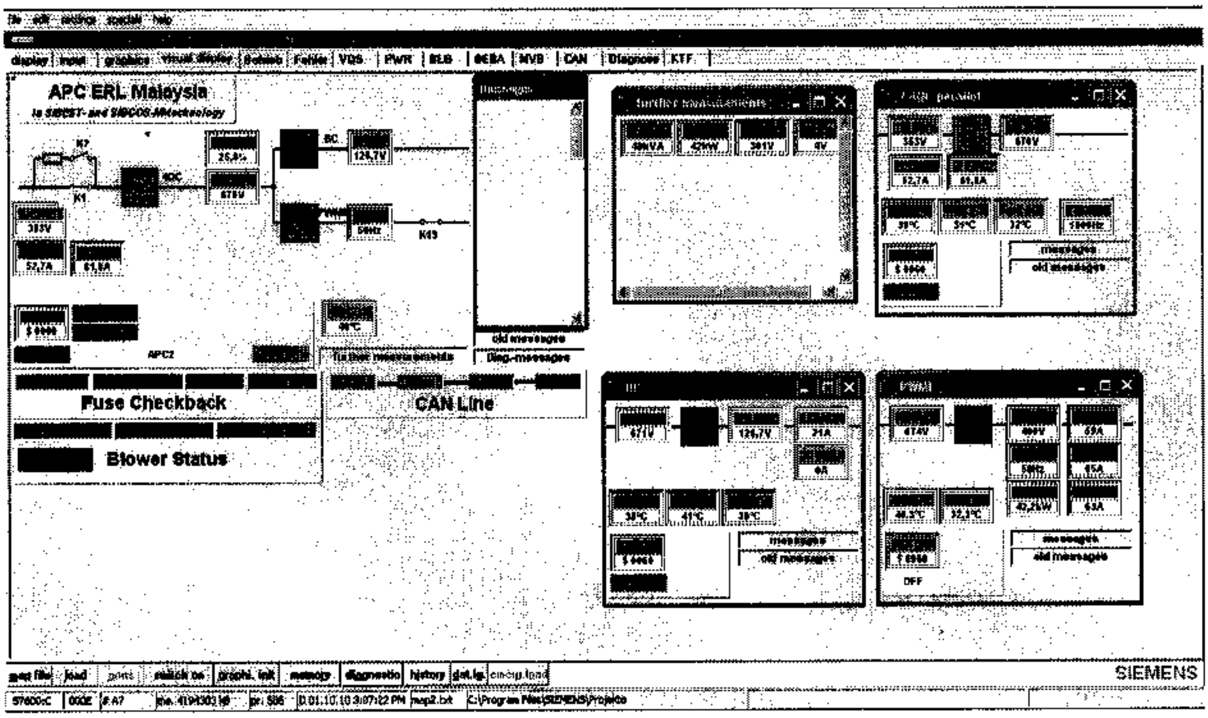


Figure 6.10: Normal APC operation displayed in SIBMON

6.2.2 Fault Finding

Faultfinding is used to pin point the failed component. In the event of failure occurrence, it will be indicated in M1300 (item 6.2.1). Readout downloading of all controllers must be performed. This is to narrow down the search area and find its causes. Some failure are interconnected with several possible causes therefore the readouts must be analyzed and come out with a summary.

Each readout analysis is to determine the cause and effect on that controller. Common failure are originated from internal fault, external fault, communication error or measuring faulty.

6.2.3 Analyzing the readout

Analyzing the readout is performed using HistoryViewer. This software will indicate the failure name, date and other important information, which the user must understand. To check the failure details, the user must first search the failure occurrence date and time and then check the failure name and other related information. It was illustrated in figure Figure 6.11.

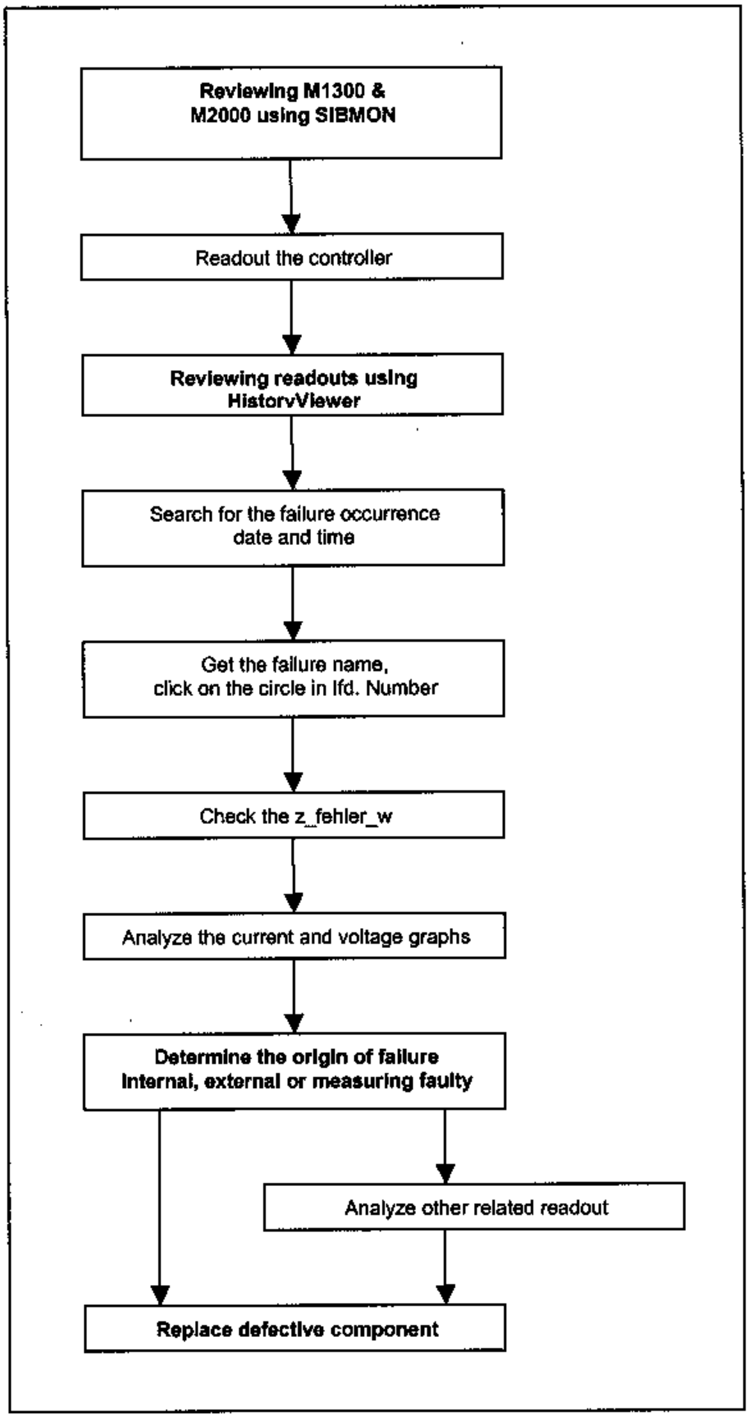


Figure 6.11: APC readout analysis flowchart

6.2.4 Checking Variable Values

The variable values are important to exanimate the system condition and pinpoint the failure. These variables are stored in the controller memory and can be retrieved by utility software. This is separated into two sections:

1) Fault Words
   Status words can be found in HistoryViewer in the "*Fault*" tab. The controller calculates this information and decides the process that it should execute. This information is interpreted in binary form and each bit has its own meaning. Refer item 5.3.2 for details.

2) Measured Values
   Measured values came from local controller, meaning that reading were measured by local M2000 controller mounted on modules and transmitted the data to M1300 via CANBus. Refer item 6.1.5 for details.

6.2.5 Checking Controller Status Sequence

The control status sequence can be checked at the "*STATUS*" box on Master project SIBMON. Move the cursor onto it and then press **F1** button. It will open up another display, this is the "*STATUS*" word meaning.

The controller sequence will always start from top to bottom of that list. When it stuck in a line, the previous state is already executed. "*STATUS*" words stating with "*$00F0*" are fault messages.

6.3 Hardware Checking and Inspection

Hardware checking and inspection is made to confirm the defective component in order to rectify the failure. The user must understand basic function of the components (which were discussed in Hardware Introduction section)

6.3.1 Detecting Short Circuit

Short circuit can be detected using continuity and resistance measurement. Any low resistance reading indicated by the multimeter when measuring between positive terminal to negative terminal is considered as short circuit. Isolating the problematic area also possible during this faultfinding to avoid false reading.

6.3.2 Detecting Wiring Breakage

Wiring breakage can be detected using continuity and resistance measurement. Any high resistance reading or "OL" indicated by the multimeter when measuring two points, which suppose to have connection, is considered as wiring breakage. Isolating the problematic area also possible during this faultfinding to avoid false reading.

6.3.3 Detecting Earth Fault

Earth Fault is detected in Master project SIBMON. Hardwire inspection such continuity and resistance measurement is required to pin point this failure. Any low resistance reading indicated by the multimeter when measuring positive terminal to ground has the possibility to be earth fault. Isolating the problematic area also possible during this faultfinding to avoid false reading.

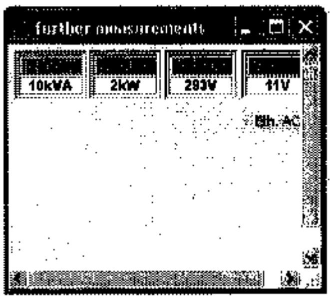


Figure 6.12: AC earth fault warning message

6.3.4 Differences between Earth Fault and Short Circuit

When an earth fault happened at BLG output, it was assumed as short circuit since it has permanent earthing connection at its negative terminal (refer to page 5 of APC wiring diagram R00 RSE 92110 YS 0001 B for the permanent earthing connection). When the positive terminal (L line in AC) touched grounding, the grounding creates a looping to negative terminal and current surge occurred. The controller will assume this current surge as short circuit.

Earth fault only occurred at 4QC input and PWMI output since these lines has no permanent earthing connection but with one rule, only one phase was touching to the ground. The Earth Detection senses a voltage reading on its earth line. Another situation is when two earth faults occurred, it then became short circuit because the grounding creates a looping on both line and current surge occurred.

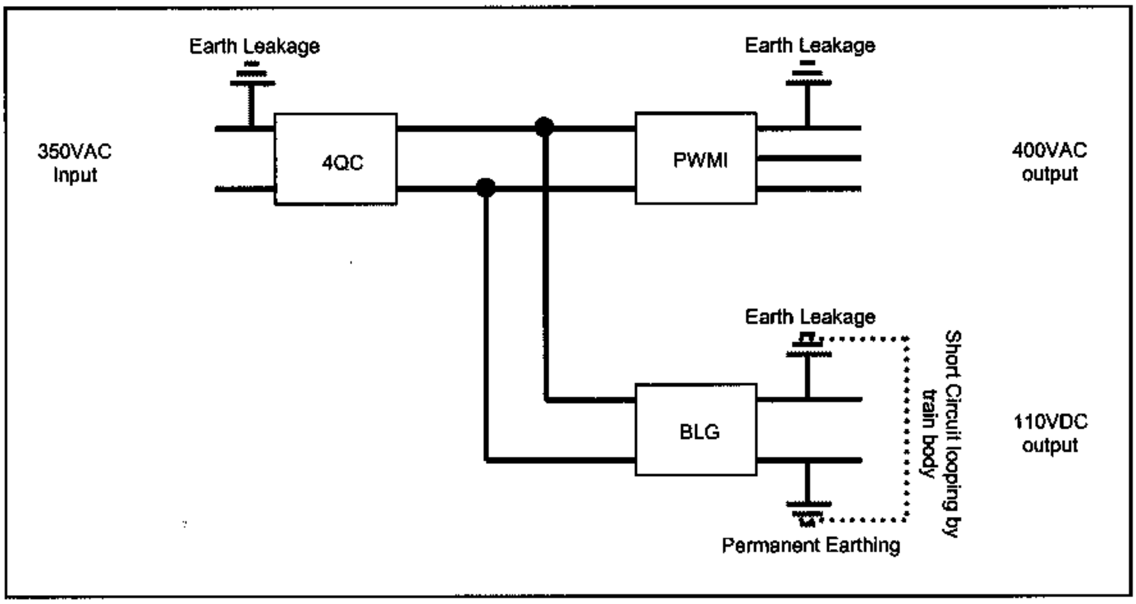


Figure 6.13: Single earth fault connection

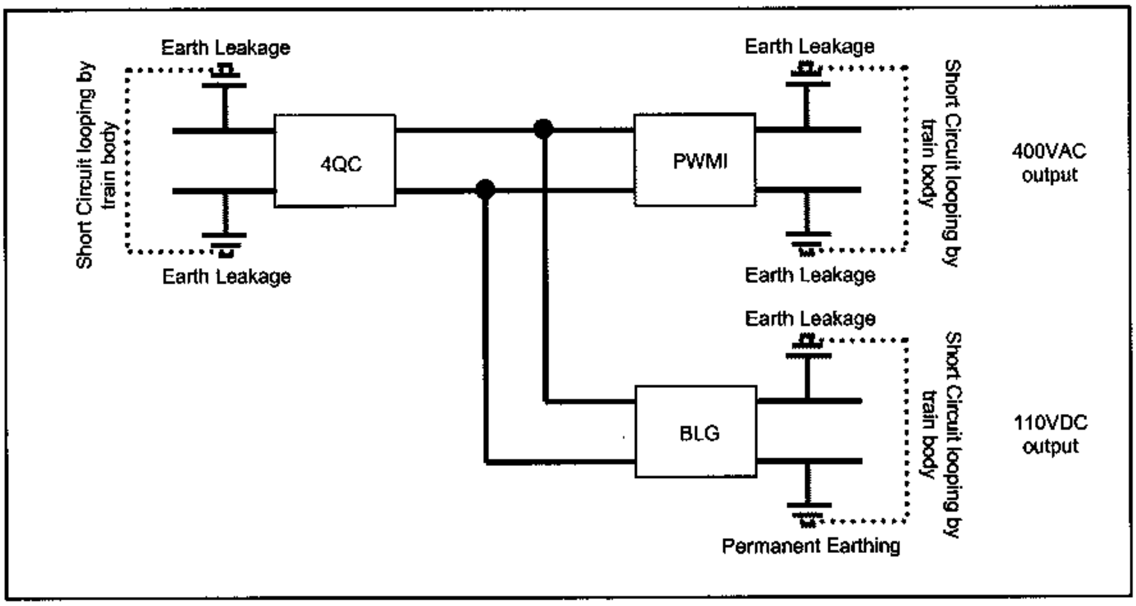


Figure 6.14: Multiple earth fault connection

When earth fault occurred, it doesn't interrupt APC operation because the current leakage is at minimal level. On the other hand, short circuit occurrence always interrupts APC operation due to current surge happened.

6.3.5 Voltage Spike Analysis

Voltage spike can be detected using 4QC readout analysis. During failure occurrence, such power tripped, 4QC will cut off its operation due to measured voltages exceed its allowable limit. At the same time, the controller will capture all the variables including input voltage measurement.

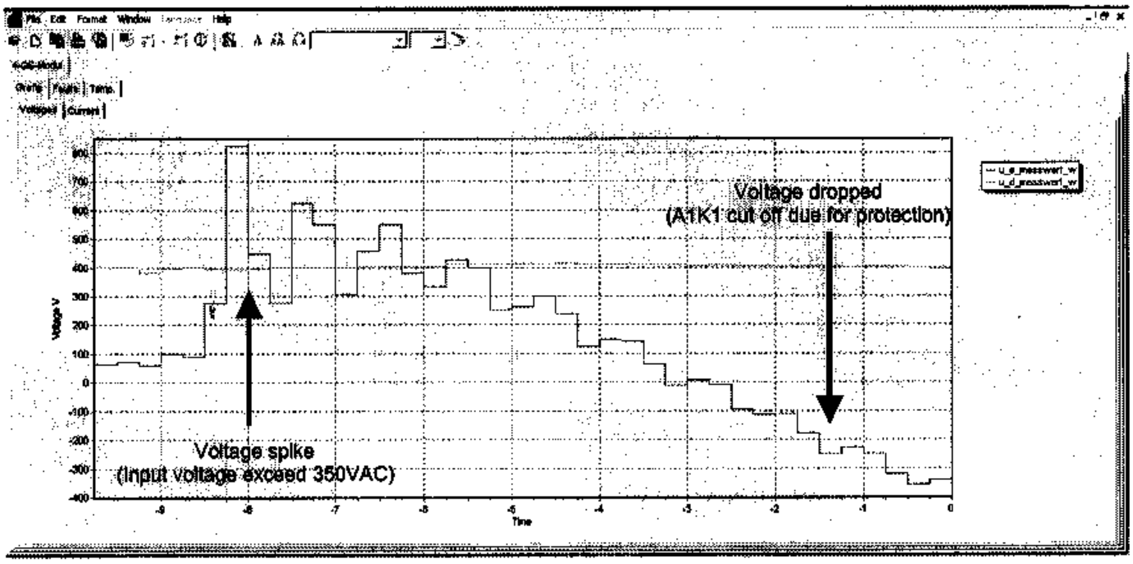


Figure 6.15: Voltage spike reading in 4QC readout

6.3.6 Checking Contactor Function

Checking the contactor can be conducted by supplying the contactor coil with electrical power. To perform this test, pull out the contactor wire from its connector (the wire from contactor to controller) and tap it to negative point nearby (the busbar on the same connector). Certain component must be powered up at start. It is also possible to check the wear and tear of these moving parts. Refer to Attachment 2 for contactor contact surface condition.

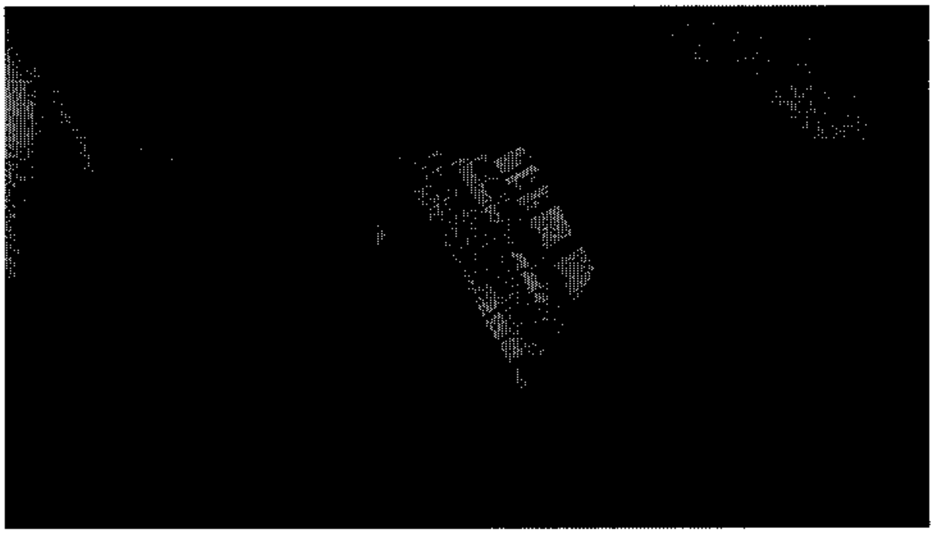


Figure 6.17: Tapping the contactor wiring to negative busbar

Another test is to exanimate the signal from controller. This can be observed at LED display on M1300 or M9000.

Note: The user must first understand the circuit layout and confirmed that there was no short circuit at the faultfinding area.

6.3.7 Checking the CANBus Looping

Checking the CANBus looping can be performed by measuring the resistance value. Each end terminal on this communication line is fitted with 120Ω buffer resistors. Furthermore, it was connected in form of serial looping. Looking for the resistance value will pin point the breakage area.

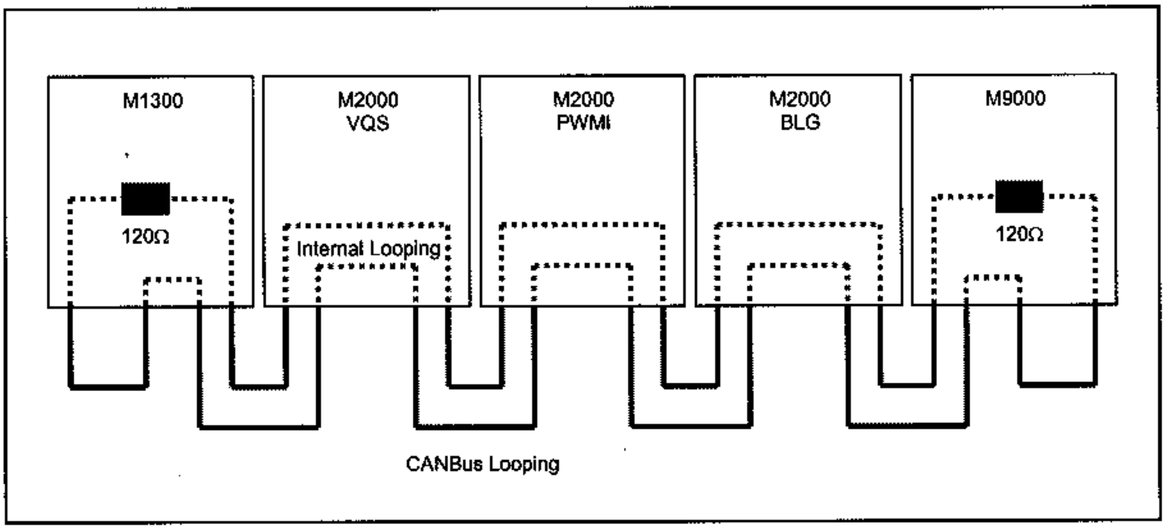


Figure 6.18: CANBus looping and termination resistor location

6.3.8 3-Phase Current Calculation

3-phase power must be symmetrical in order to work properly The PWMI measures two of its output current, which are U phase and V phase while W phase (output from module PWMI J1) current is calculated value. These values are displayed at Visual Display and Graphic function of SIMBON.

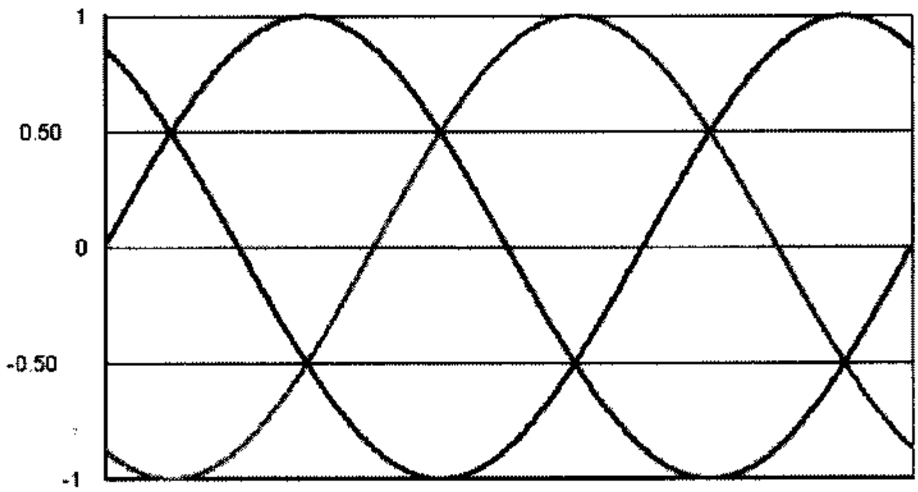


Figure 6.19: 3-phase sinusoidal waveform (voltage or current)

Referring to figure 6.19, each of the three colors represents the 3-phase current sine waveform. Note that when red is at the positive peak, both blue and green are at 50% negative, therefore the sum of all three currents is zero.

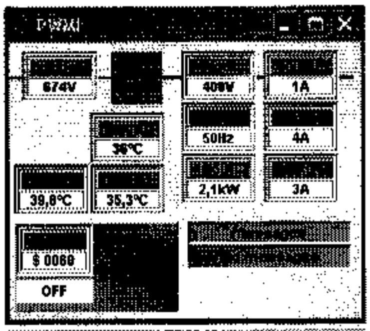


Figure 6.20: PWMI output current values

The calculation made is:

$$U_{phase}\text{ Current} + V_{phase}\text{ Current} + W_{phase}\text{ Current} = 0A$$

$$1A + (-4A) + W_{phase}\text{ Current} = 0A$$

$$W_{phase}\text{ Current} = -3A$$

6.3.9 Detecting Missing Phase

Missing phase makes 3-phase motor to be noisy and certain circuit breaker to tripped. It can be detected using PWMI project SIBMON. The user must analyzed the graph waveform which available in Graphics Function (item 5.2.3) and check for imbalanced lines.

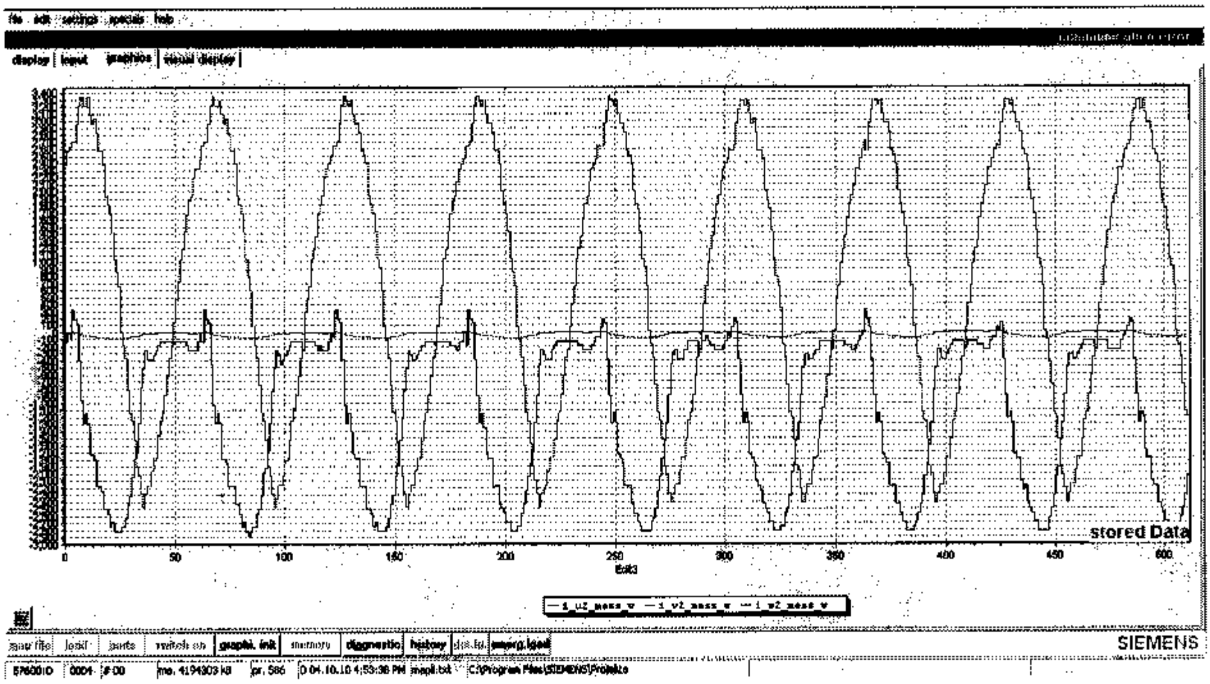


Figure 6.21: Imbalance PWMI output current waveform

Referring to figure 6.21, each of the three colors represents the 3-phase current sine waveform. Note that the red (U phase) is almost linear (straight line), while the green (V phase) are complete sine waveform. This indicates that PWMI is working but there is something wrong with its operation where the U phase is not triggering. The blue (W phase – calculated value) were merely half of complete sine waveform because it was affected by missing U phase.

6.3.10 Checking Blower Block

Blower block can be triggered into high or low speed without ever waiting for temperature changes. By turning OFF A1-Q13, the blower fan will run at high speed at once. It will enter low speed mode if only circuit breaker A1-Q12 were tripped. If both breakers are tripped, APC will stops its operation.

Figure 6.22: Tripped blower circuit breaker indication

7 Attachments

Attachment 1 – SCHALTBAU Power Reducing Circuit Technical Data - for A1K1
(Ref. No. R00.SUP.M92110.PG.1002.A)

Attachment 2 – SCHALTBAU Condition Assessment of Contact in Switchgear - for A1K1
(Ref. No. R00.SUP.M92110.PG.1002.A)

Power-Reducing Circuit for High-Power Contactors

Description

200/95

Zust.	Änderung	Datum	Name		Datum	Name	
				Bearb.	10.07.95	Foth	Description Power Reducing Circuit 5500 AW / 6800 AW
				Gepr.	10.07.95	Junck	
				Norm	10.07.95	Gö.	
2	ÄA-12700-06	30.05.06	Bir	SCHALTBAU			1-0650-252438
1	1-223-00 Bl.1-7	17.10.00	Foth/Kru				Blatt 1 / 7 Bl.
				Urspr.			Ers.f. / Ers.d.

Table of contents

1 General

1.1 Construction

The circuit is available in two different variants.

- The board is delivered together with one of Schaltbau's high-power contactors (series C152 to C159), mounted directly beneath the contactor itself and already connected to the coil of the contactor. No modification in mounting the contactors is necessary in reference to contactors without the circuit. The only change is an additional inch in height.
- For other type of contactors the circuit is available in a separate box. Refer to figure 3 for dimensions.

1.2 Application

Contactors need a high current during turn-on for closing the contacts. After turn-on only a fraction of the current is needed for holding. Without any additional means the contactor has to be designed to stand the unnecessary high turn-on current during the entire turn-on time which results in large coils and a high temperature rise in the coil. Also, if the contactor is being used in a battery powered system, the design has to take into account large variations in coil voltage and the change in coil resistance due to warming up the coil-wires.

The electronically power-reducing circuit lets you choose different values for turn-on current and hold-current as well as for the turn-on time (the time the turn-on currents flows), thus allowing for optimal flexibility.

The values of these currents are - within the limits of the data - independent of the coil voltage and the coil temperature. This way, all over power consumption is largely reduced and the temperature rise in the coil minimal.

2 Description (refer to figure 1)

The circuit lets you control the contactor just as a conventional one. Connect your control wires to X1-1 (+) and X1-2 (-) and turn on the voltage. The power-reducing circuit will go into operation. Right after the ***minimum turn-on voltage*** is being detected, the circuit will supply the coil with the ***turn-on current*** (adjustable by R34) by opening transistor V1 and controlling the pulse-width of V2 accordingly. After the ***turn-on time*** (adjustable by R10) the coil-current will be reduced to the holding-value (adjustable by R37) by changing the pulse-width to a lower value. V4 allows free-wheeling of the coil current. Refer to figure 1 for details.

The circuit is completely current-controlled, thus independent of supply voltage and coil resistance.

Turning off the contactor is done by simply turning off the supply voltage. If the circuit detects under-voltage at its input, V1 will be closed thus connecting the zener-diode V3 to the coil in order to decrease the coil current as fast as possible (Using just a diode would lead to a very slow decreasing and a slow opening of the contacts producing powerful arcs and reducing the life-time of the contacts considerably!).

It is also possible to connect the supply voltage to X1-1 and X1-2 at all times during operation and control the turn-on/off of the contactor by the control-input X3-1 and X3-2. A „short“ means turn-on, an „open“ turn-off. Note that this feature is disabled with a jumper over X4 when delivered. You will have to remove the jumper in order to use this additional input.

3 General Schematic

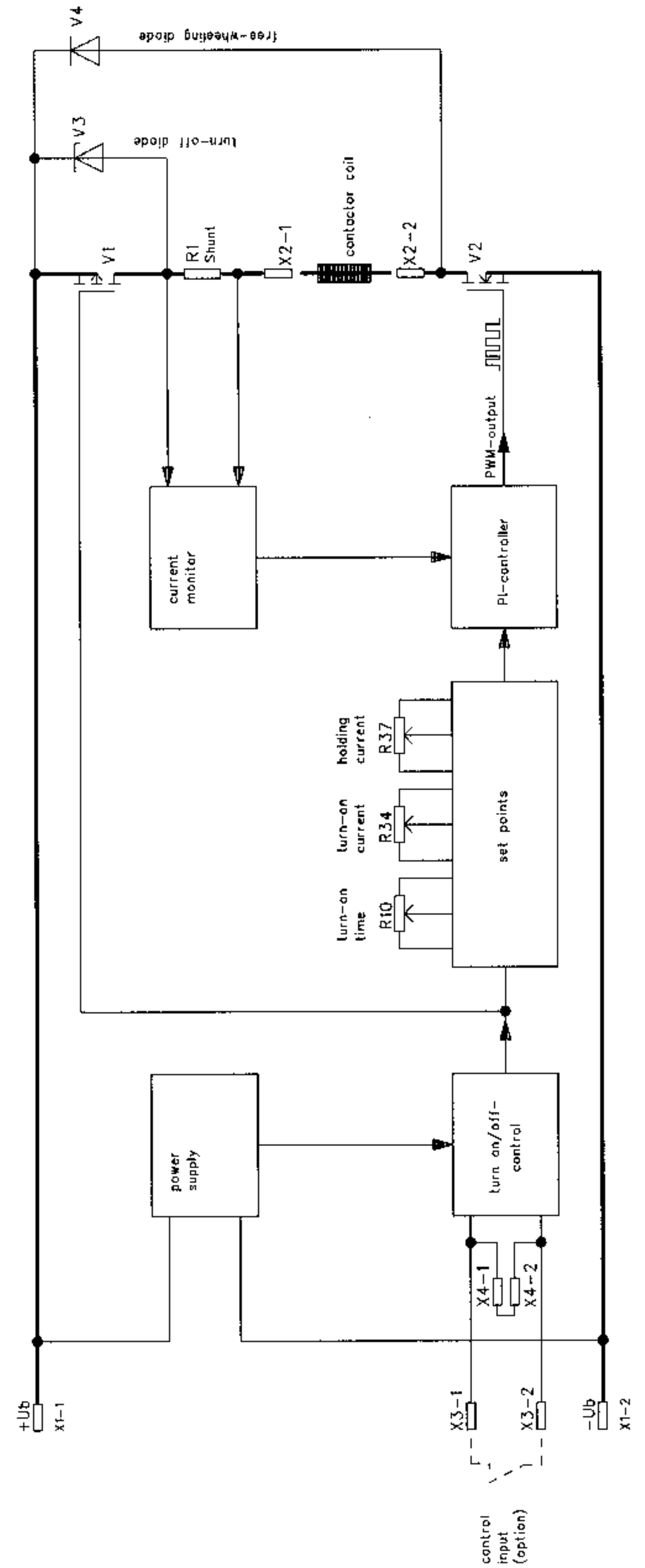
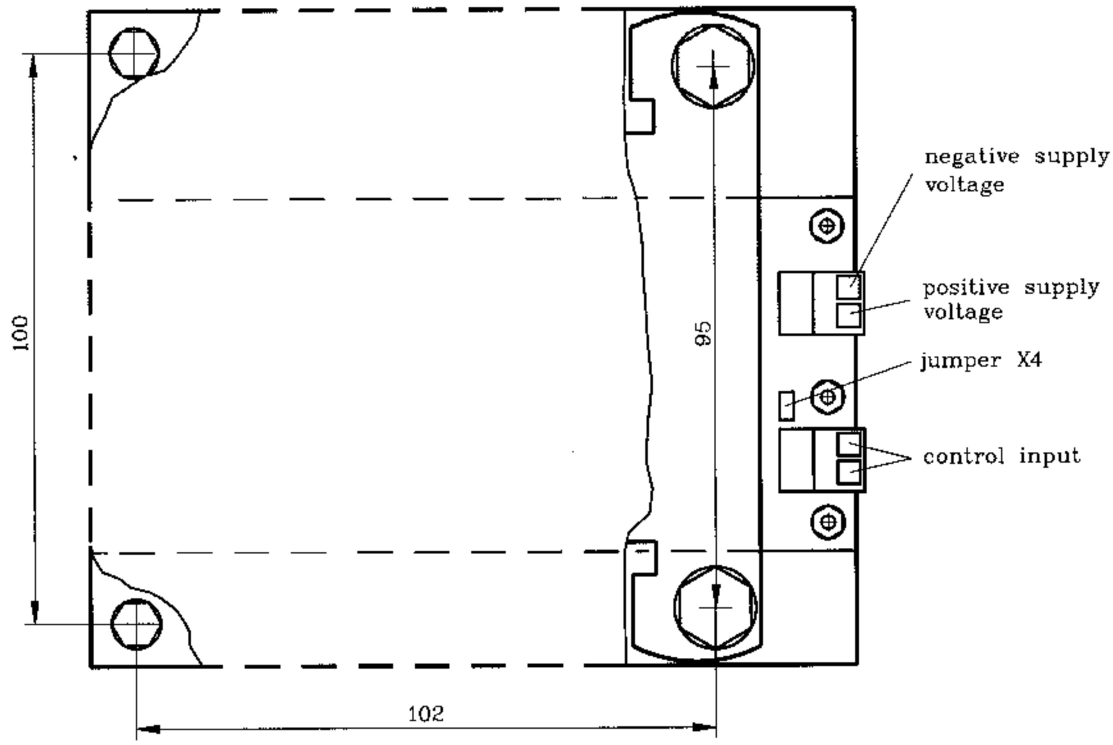


Figure 1: General schematic

4 Dimensions/ Connection Scheme

4.1 Variant 1(directly mounted beneath contactor)



(all dimensions are in millimeters)

4.2 Variant 2 (with seperate housing)

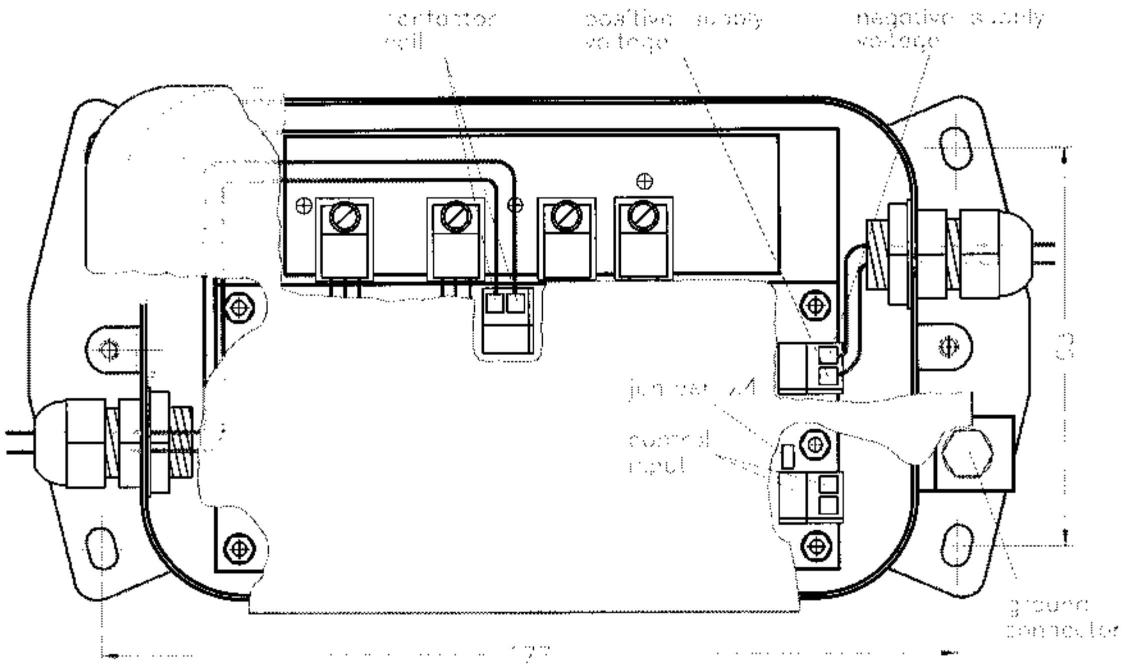


Figure 3: Dimensions of housing

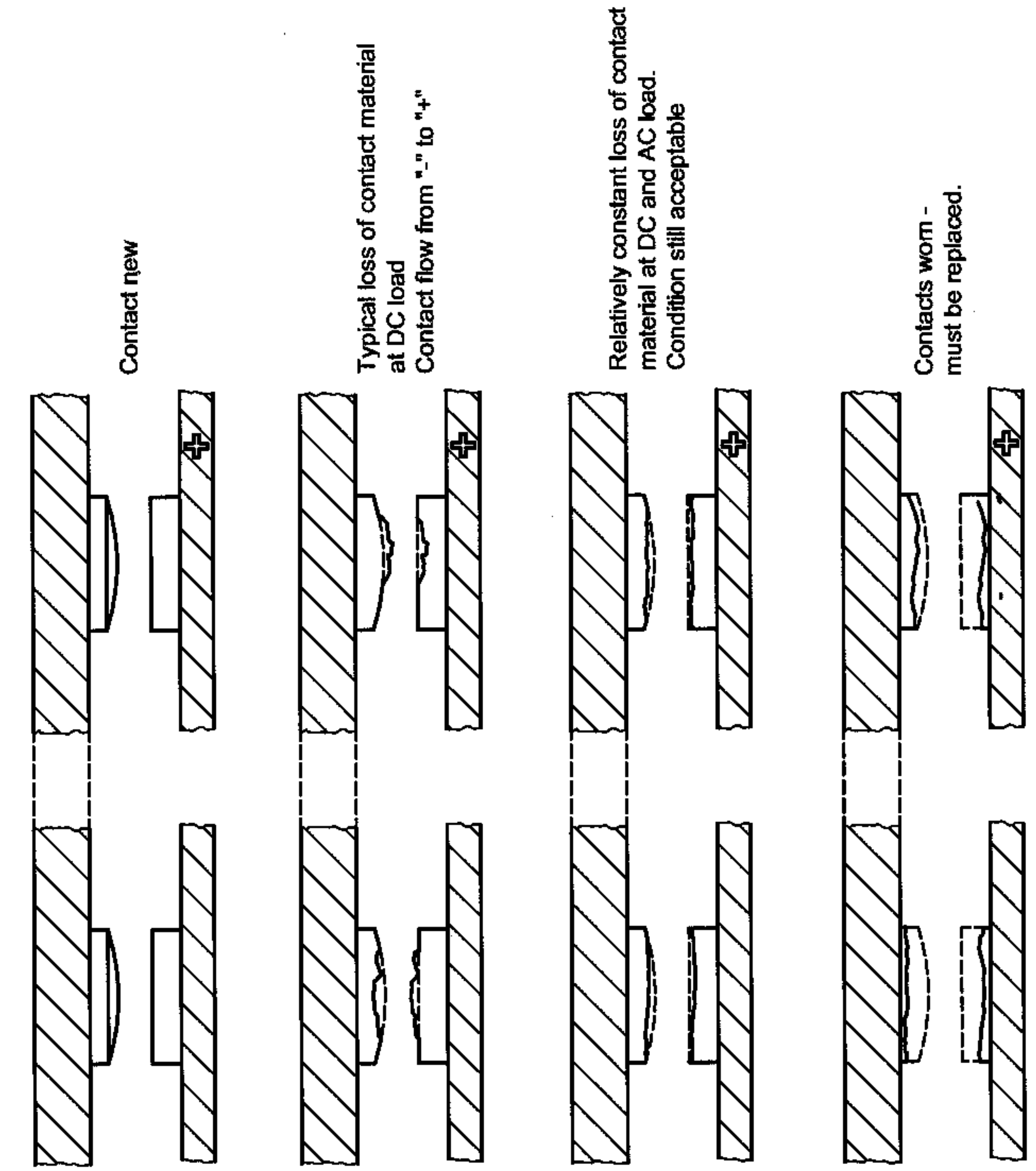
5 Technical Data

Supply voltage range:	-30% up to +25% of nominal value
max. turn-on current:	12 A respectively 14 A
max. turn-on time:	150 ms respectively 300 ms
max. holding current:	3,5 A
max. no of throws/min:	20/min.

CAUTION

The user has to take care that during inrush-current-period the supply-voltage doesn't fall below the lower level of the voltage-range (U_{nom} - 55%).
Otherwise the device will be destroyed.

1	2	3	4



Remaining height of contact material should be at least 0,3 to 0,5 mm above carrier material.
This is true for both the contact bridge and the fixed contacts

CAD-Zeichnung (1.7)

	Datum	Name
Bearb.	07.12.06	RuB
Gepr.	07.12.06	Blr
Norm.	Siehe PDM	

Condition assessment of contacts in switchgear

SCHALTBAU

1–K000–KONTAKT

Blatt E1
E1 Bl.

Zust.	Änderung	Datum	Name	Urspr.	Ers.f.	Ers.d.