Amateur satellite ground station: Troubleshooting and lesson learned

F Z Ali¹, S N M Rahim¹ and M H Jusoh¹,²

¹Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia
²Centre for Satellite Communication, Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

fatimah_zaharah@uitm.edu.my, naddp1389@gmail.com, huzaimy@uitm.edu.my

Abstract. Few troubleshooting steps have been taken during the non-operation period of UiTM ground station (UiTMSAT) where some of the main equipment and systems were malfunction. After few resolutions performed, the root cause of the defect was detected. The issue occurred due to the lightning strike that has transferred abundant amount of electricity to the devices in the monitor room. This paper explains the resolution steps that were taken to resolve the issue in the ground station. The maintenance is performed on radio, rotator controller, rotator interface, terminal node controller (TNC) and the software used for the satellite operation. The issues on the radio and rotator devices made some difficulties in using the operation software which are the SatPC and BIRD operation software. Several attempts have been done and through this, many lessons were learned by the ground station operator. These lessons were shared to other BIRDS members during the ground station workshop at Kyushu Institute of Technology (KYUTECH), Japan.

1. Introduction

Artificial/man-made satellite’s operation has started since the 1950s and its technology in term of satellite’s design and space communication is continuously being improved to serve the world. In this communication, ground segment plays an important role as well as the satellite itself. Ground segment including control basically done at a satellite ground station. Here, the operators of satellite ground station can manage, track and monitor the satellite on space. The National Aeronautics and Space Administration (NASA) is one of main space players in its notable contributions in the space and ground communication technology. In Malaysia, Malaysian Space Agency (MYSA) is governing the space development and activities. MYSA also has an established satellite ground station whereby it supports the satellite monitoring and studies such as discussed by [1]. Aside from satellite ground station managed by government for the benefit of the residents/broadcast, there are several cases where a satellite ground station has been developed for the purpose of education such as [2] and [3]. Another example of student ground station development can be seen at UGM ground station, Indonesia [4] in which their ground station system uses Yagi antenna for satellite tracking and focusing more on LEO satellites. Similarly, UiTM also established a satellite ground station in order to support UiTMSAT-1, the first UiTM’s Nanosatellite in space via the BIRDS-2 CubeSat project. The satellite ground station at UiTM has been operated since its establishment by end of 2017 as illustrated briefly in the result from satellite’s monitoring at [5] and [6].
In term of UiTMSAT-1’s current status and condition, it requires a continuous satellite ground station operation. As noted, the system in the ground station consist of sensitive equipment and devices. It is critical to do frequent assessment or maintenance towards the system and also the operation’s procedure. The operators that are assigned to operate the UiTM satellite ground station has been trained by members of BIRDS-2 and other qualified figures. However, unexpected situation may occur, and it is vital to properly handle the crisis. This paper shares the crisis happened at the UiTM ground station in which the heavy rain with constant lightning has disturbed the system and how it was overcome. The situation has been resolved after some investigation and some help sought from the experts, yet this experience may provide several meaningful lessons for the ground station operators.

2. Methodology
In October 2019, it was reported by one of the ground station operator where the computer in the monitor room cannot be turned on. Several checking was performed and it showed that the desktop of the computer was unable to receive the power supply. This proved that the motherboard of the computer was burned. At this point, the operators found the cause of the defect was because of the lightning strike since the night before the incident happened, there was heavy raining and storm. The motherboard worked again after it was replaced with the new one. The CPU, RAM, ROM, and the hard drives were still the same and thus, no changes ensued on the computer system.

However, there were issues in connecting the SatPC software and BIRDS Operation software to the radio, TNC and rotator. When examined, there was no connection detected by the computer from mentioned devices through the USB port based on the computer’s device manager. Thus, troubleshooting steps were taken for all main equipment in the monitoring room. Next subsection will explain the process that have been taken in solving the issues.

2.1. Yaesu Rotator Interface GS-232B
It was found out that the rotator interface that was used to connect the computer to the rotator controller cannot be turned on. Continuity test and voltage measurement through multimeter were performed on the device’s connector and power port, as well as the cables used for the connections. From the inspection, it showed that the fuse of the power cord cable was burned. See figure 1.

![Fuse connected on power cord of rotator interface.](image)

**Figure 1.** Fuse of rotator interface.

The fuse was replaced with the new one with the same amount of 500 mA as the devices current capacity requires only 70 mA. Similar fuse must be used to avoid damages on the device’s circuitry. After the replacement was done, the rotator interface can be turned on again.

This rotator interface is very important in order to control the antenna rotator from the software on the PC, as the rotator controller can be directly connected to the computer [7]. The establishment of the connection from rotator controller to rotator interface and then right to PC would allow the antenna to be controlled from the SatPC software when the port number is properly entered.
2.2. **Yaesu Rotator Controller G-5500**

After the rotator interface was successfully turned on, the connection to the PC was still failed. The connection of the rotator controller to the PC must be done through the rotator interface which becomes the ‘intermediary’ between the PC and the rotator controller. The connection was established through 8 pin cable for the connection from rotator controller to the rotator interface, and RS232 serial converter cable for connection from rotator interface to PC. Both cables have been inspected with continuity testing. The faulty cable has been replaced with new one and the connection was successfully recognised by the PC.

However, the effect of the lightning strike on the rotator controller was not only on the connection or particularly the cables but also the circuitry of the device. It was find out that both of the analogue meter of the rotator controller (azimuth and elevation) was out of order where the needle of the meters did not move even when the buttons of azimuth (right and left) and elevation (up and down) were pressed. Refer figure 2. In spite of the failure shown by the meters, the antenna was successfully moved accordingly when the buttons of azimuth and elevation were pressed.

![Figure 2](image)

**Figure 2.** The meter reading of both azimuth and elevation of the rotator controller did not show any movement even though the up, down, left, and right buttons were pressed.

Yet, the real value of azimuth and elevation on the SatPC software (SDX server) were 0.00 as a reflection of meter reading. This made the ground station operator difficult to do the operation as the angle of azimuth and elevation of the antenna cannot be automatically changed according to the passing satellite.

2.3. **Radio ICOM IC-9100**

The radio experienced the same error as the other devices when the connection to PC was established. Thus, the initial resolution to this problem was to check the cable used for radio-to-PC interface and the connector of the radio through the test of current continuity. The result showed that the USB connector that was used to be the main port for PC connection was damaged. This port is very crucial as it provides the simplest and direct way to connect the radio to PC through a single USB type B cable via USB connection. Since the USB port was damaged, the other port must be used in order to establish the radio-to-PC connection.

Thus, CI-V control jack port was used instead. This CI-V control jack port has a similar port type as audio port. Therefore, auxiliary cable was used for the connection. However, unlike the USB port, CI-V control jack port doesn’t provide direct connection to PC. Similar to other ICOM radios, ICOM IC-9100 uses CI-V system to allow the radio controlling from the computer. Through the special feature of ICOM IC-9100, Universal Asynchronous Receiver/Transmitter (UART) communication can be done through USB standard connection for interfacing the radio with the PC. Thus, the CI-V data format can be used by the PC with the USB connection [8]. But since there is no direct interfacing from CI-V control jack port, an interface connection must be implemented in order to ensure PC to recognize the connected CI-V system port.

The interface for CI-V control jack port was ICOM CT-17. This interface convert the signal from the CI-V control jack port to USB for PC linking. RS-232C cable was used to establish the physical
connection. See figure 3 for the connection of radio-to-PC through the implementation of ICOM CT-17 interface.

![Image](image_url)

**Figure 3.** ICOM CT-17 interface was used in between the radio and the PC.

2.4. **Terminal Node Controller (TNC): Kantronics Packet Communicator 9612 Plus**

TNC is an essential element in tracking the passing satellite as it allows the signal sent by the spacecraft to be received and understood by the software used for the ground station operation. TNC acts as a modem that provides the process of packeting the data or signal from the satellite and vice versa [9]. On the other words, TNC works as the packet assembler and dissembler. The packeted data will be sent to the operation software for decoding process.

Besides, as a modem or technically an interface between radio and PC, TNC is responsible to change the frequency of the radio based on the frequency on the operation software. That is why TNC is essential equipment for radio connection and operation software. The frequency on the radio must be similar with the frequency showed on the software.

In inspecting this main device, the continuity test was performed. There was no damaged found during the troubleshooting except the RS232 cable that was used to connect the TNC to PC. The issue solved after the cable was changed.

3. **Result and Discussion**

Based on the troubleshooting steps that were performed on each main equipment in the monitoring room, it was clear that the damages were caused by the excessive current flow from the main power supply to the devices which affected not only the circuitry of the devices but also the internal copper of the cables and connectors. The excessive current flow came from the effect of lightning strike as the ground station is located on the top floor of the 71 meter building.

Even though all the devices in the monitoring room were shut down properly including the computer, the electronic devices were still intact with power supply connection. The power cords of the devices were connected to the power outlet even though the switches were turned off. Due to this, the excessive current from the lightning strike can still flow through the conductor path and pass to the turned off devices.

UiTMSAT was equipped with safety measure for lightning bolt through the installation of lightning protection system that consisted of 7 meter lightning arrestor pole and two Surge Protection Devices (SPDs); one is to protect the rotator equipment and another one is to protect antennas and outdoor cables [10]. Similar to arrestor pole, copper tape was used by SPD for grounding. The grounding connection was established from the grounding place located at the ground floor of the building.

The issue of the lightning strike effect occurred when one of the copper tape that was attached to the SPD outside the monitoring room for grounding purposes were missing. This caused an incomplete grounding system. Thus, when the lightning stroke one of the antenna’s perimeter, the excessive charges from the flash that should be flowed to the ground, has moved to the equipment in the monitoring room. It is because there was the sole conductor path available from the antenna to the equipment for the
propagating electrical charges to flow. As the result, the equipment received the unbearably abundant of current flow which affected and burned the circuitry of the devices, cables, and connectors.

3.1. New Grounding for UiTMSAT Ground Station
The safety precaution was improved by changing the grounding system from the initial place at ground floor to the nearest main circuit board (MCB) at the same level of monitoring room. The grounding system was added to the rack that holds the main equipment of ground station for further safety measure from lightning or surge effects. Refer figure 4 for the grounding system installed on the mentioned rack.

![Equipment rack](image)

**Figure 4.** Grounding connection from MCB to the equipment rack.

3.2. New Procedure Added for Ground Station Operation
It was learned that the event was because of the lightning strike and the missing copper tape for grounding system. Thus few procedures were added for the ground station operation, particularly after the operation ended. Previously, the operation ended by turning off all the equipment including PC and switches at the power outlet. As new procedures added, the operator must ensure there is no connection between the equipment and the power outlet which means, after all the equipment are turned off, the power cord must be disconnected from the power outlet. This is to make sure the excessive charges from lightning will not propagate to the devices through the power cable.

4. Conclusion
The event gave new lesson to the operators of UiTMSAT ground station where concern on lightning or surge must be crucially taken into account. The lightning strike has damaged mostly the main devices in the monitoring room that affected the operation activity of the satellites. Thus, to avoid the same incident from reoccurring, new procedure was added where the operator must ensure all the connection between the indoor equipment and outdoor equipment such as power cord, antenna cable, and LAN cable must be disconnected. In the other words, the operator must ensure there is no possible connection established after the operation ended. This is to guarantee there is no way for the surge or electrical charges from lightning to pass through to the devices, and must only flow to the ground through the available copper tape.

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