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Novel Electricity Distribution Pillar Development

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Abstract:
Transmission and distribution of electrical energy is one of the most critical aspects of electrical power supply. Conventional distribution or feeder pillars do not allow physical identification of line/lines required for upgrade to unload it before it results to hazard and catastrophic damage. It is important that, both incoming phases and outgoing lines are secured to avoid escalating damages by isolating the faults before failure or any damage occurs. Novel Electricity Distribution Pillar is designed to improve safety of lives and properties by ensuring quality power is being provided during distribution. The innovation enables independent control of outgoing lines wherefore faults can be easily isolated and reported promptly without interrupting other lines. The equipment ensures that incoming phases and outgoing lines are adequately fused which serves as the secondary protection system. The track records of power supplied are first taken and measured at the incoming phase fuse link via a voltmeter and current transformers connected to each phase independently. The introduction of Novel Electricity Distribution Pillar proposes to enhance operator safety, reduction in electrical hazards leading to smooth maintenance operations and better electricity supply in Nigeria.

Keywords: Electricity, Distribution, Hazard, Feeder, Pillar, Safety

INTRODUCTION

Continuous enhancement of human and industrial activities engendering corresponding increase in the use of power both domestically and in industries, prompts the need to adequately protect our homes, industries and every other electrical appliance using electricity. After the generation and distribution of electricity, it cannot be assumed that the consumers will efficiently manage the power ensuring powering off gadgets and devices when not in use. Inefficient management can lead to losses and may constitute serious problems to the load users as well as the operators. In order to have adequate control and full management of power supplied without shutting down the generation or transmission station which will affect the entire user for the purpose of maintenance at the end user point, a feeder pillar station is set up to either isolate a fault or a line for any operation as the case may be. A distribution pillar (also known as a power box, feeder pillar, or feeder pillar box) is a cabinet which is used to house electrical distribution equipment, consisting of a panel which embodies all other sub-units of the feeder pillar, bus-bars in which are connected the incoming and outgoing lines, an ammeter which records the voltage across the bus-bars, the fuse holders holds the fuses, high-rupturing-capacity fuses for making contact and for protection purposes (Azuatalam *et al.*, 2014). Feeder pillars act as a central circuit in control and distribution of electricity to outgoing circuits downstream to the feeder pillar. It is designed to provide each circuit protection, along with the capacity to be easily controlled. However, feeder pillars over the years have received significant attention to be investigated, on how to improve its protection abilities to safeguard lives and properties.

The common failure experienced by electrical appliances is associated to phase failure which could be caused by either unbalanced voltage, single phasing or phase loss, overloads, power outage, overvoltage, under voltage, or phase reversal. Similarly, since phase failure cannot be avoided in our everyday electricity consumption, it is paramount to note that phase failure detector is a very vital protective device that must be taken seriously (Ezema, 2012). Phase failure detectors enable operators to fix the faults and restore power in due time. The fixing of phase failures is very delicate as most fatal accidents that lead to loss of lives and property such as flashover and arc flash are experienced during the work. Plates 1 and 2 depicts the conventional feeder pillars.

Plate 1. 4-Way LT Feeder Pillar

Plate 2. 6-Way LT Feeder Pillar

These types of feeder pillars do not have an incoming switch nor fuse. Rather, the outgoing lines have fuses, while, the incoming phases are connected directly to the phase bus bars, thus, the operator do not have utmost control over the circuit. These conventional feeder pillars cannot be used to effectively allocate and distribute electrical energy without putting the operators' lives at risk and must have to rely on the substation to turn off the incoming lines before work can be done with limited risk, thus, affecting the consumer until power is restored after maintenance. About 80% of electrically related accidents and fatalities involving "Qualified Workers" are caused by arc flash / arc blast. Similarly, the feed pillars shown in Plate 3 and 4 below, have a slight difference from the feeder pillars described in Plate 1 and 2.

Plate 3. 4-Way LT Feeder Pillar with Circuit Breaker

Plate 4. 4-Way LT Feeder Pillar with Manual Switchgear

These types of feeder pillars come with incoming circuit breakers/switchgears, but, turning on and off requires human involvement which can result to fatal accidents. The feeder pillar shown in Plate 5 has an added advantage with additional fuse for the incoming lines, but will still require human presence to disengage fuses or turn off switches for maintenance. Although, when switches are turned off, all the lines are also disengaged together with the faulty line.

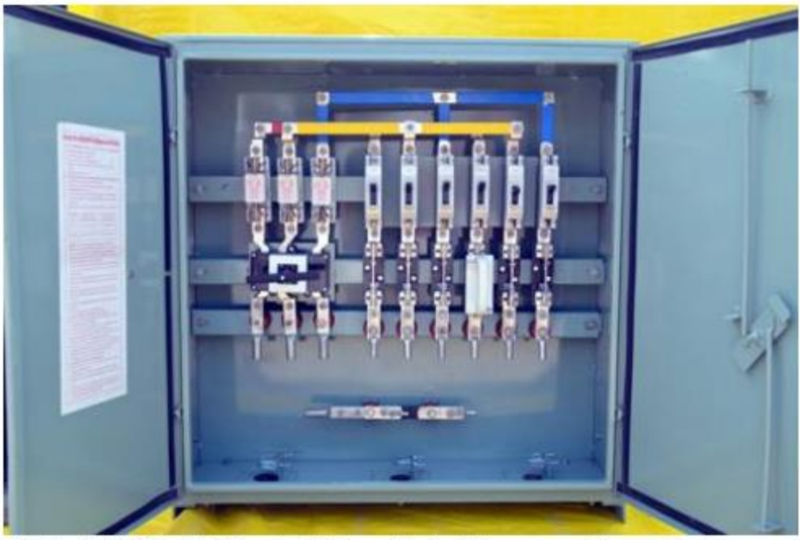


Plate 5: 2-Way LT Feeder Pillar with Switchgear and incoming fuse

The conventional distribution or feeder pillars do not serve well as long as effective energy distribution, real-time and actual fault detection, and safety are the priority. The conventional feeder pillars do not have the ability to monitor the power supplied and power evacuated. Likewise, the safety of the electrical appliances solely depends on the breakers and fuses which in some cases tend to fail in operation, thus, endangering the stations and the end users. In addition, a vast majority of electrical incidents occur because people are working on or near equipment that is either thought to be dead but is still live or by those working on equipment that is known to be live but they do not have the adequate training or are not using adequate protection equipment.

Furthermore, the conventional feeder pillars do not have tracks and records of load buildup over time. Unfortunately, excess load on the lines is usually identified when the overloaded fuse cuts/melts, thus, increases the maintenance cost of the system. Similarly, a lot of fuses are damaged due to human factor when allocating energy. Likewise, the fuse base develops mechanical faults due to frequent pulling and inserting of fuses over time, which makes the fuse base loose grip of the fuse link. This leads to partial contact and eventually, can lead to fire outbreak when not addressed immediately, whereby, the operator may possibly experience arc flash or flashover. To curb all these anomalies, secure installations and reduce damage emanating from the employment of conventional electricity distribution pillars, this novel equipment is built to identify and isolate faults promptly without interrupting other lines. The equipment ensures that incoming phases and outgoing lines are adequately fused which serves as the secondary protection system. The track records of power supplied are first taken and measured at the incoming phase fuse link via a voltmeter and current transformers connected to each phase independently.

MATERIALS AND METHODS

The isometric drawing of the Novel Electricity Distribution Pillar is shown in Figure 1. It depicts the outside view of the device when the entire components are enclosed. The orthographic view of Pillar is shown in Figure 2 while the exploded view is shown in Figure 3. The instrument has a Control Compartment (1) which houses all the monitoring and actuating components, and the Switching Compartment (5) which houses all transmission connections and switching devices. In addition, as ventilation is required to evacuate warm air, two Louvers (4) are provided for each compartment, both located at the lower sides of the compartments. While behind the Top Cover (6), addition Louver is made for warm air escape route for both compartments. The maximum size the device occupies is (1453 X 330 X 1135 mm) (L x B x H). It also shows the positioning of the cable input via the Cable Glands (31), which are located at the top right and left bottom of the Switching Compartment (5).

Novel Electricity Distribution Pillar comprises of the Control Compartment (1), Front-Lower Cover (2), Louvers (4), Switching Compartment (5), Top Cover (6), Cover 1 (7), Cover 2 (8), Seal 1 (9), Seal 2 (10), Switchgear (11), Current Transformer (12), HRC Fuse Link (NT – 400) (13), HRC Fuse Link (NT – 800) (14), Keylock (15), SP Fuse Base (16), Phase Bus bar Red (17), Phase Bus bar Yellow (18), Phase Bus bar Blue (19), Phase Bus bar 400A – Blue (20), Phase Bus bar 400A – Red (21), Phase Bus bar 400A – Yellow (22), 6A Miniarture Circuit Breaker (23), 10A Relay (24), 12V DC Adapter (25), Analog Meter (26), Digital Meter (27), Load Indication (28), Power Indicator (29), Rowtina Smart Module (30), Cable Gland (31), Bus bar Insulator (32), Neutral Bus bar (33) and Line Current Transformer (35).

The 3 Phases power supply and Neutral cables are passed through 4 Cable Glands (31) under the Switching Compartment (5), each in a single hole. The phases are connected individually to the lower end of the 3-SP Fuse Base (16) in which HRC Fuse Link (NT – 800) (14) are mounted on. The HRC Fuse Link (NT – 800) (14) are designed to cut/melt when Load current is beyond 800A. Each of the 3-SP Fuse Base have one Current Transformer (12) right around the SP Fuse Base (16) and Phase Bus bars (17, 18 and 19) to constantly measure the amount of accumulative current drawn on each of the Phase Bus bars (17, 18 and 19). Depending on the current demands, more than two lines can be drawn from each of the Phase Bus bar (17, 18 and 19). Two lines of each of the Phase Bus bar 400A (20, 21 and 22) were drawn to each of the Phase Bus bar (17, 18 and 19) and connected to two separate 400A Switchgear (11) as shown in Figure 4, thus, splitting the Load current into two. Also, each 400A Switchgear (11) operates individually as each can be maintained which out interrupting another. Similarly, at the other end of the two 400A Switchgear (11), the SP Fuse Base (16) are also connected to each of the terminals. Whereas, the other end of the SP Fuse Base (16) serves as load connection points, where each line has a Line Current Transformer (35), which also measures the current consumed by each line independently. Simultaneously, current measured is alongside with the voltage supplied on a particular phase independent of the other phase. Although, the general voltage measured for each phase and power supplied to the control systems are drawn from the phase connection points of the SP Fuse Base (16) before fused with the HRC Fuse Link (NT – 800). This will enable the control systems powered for communication and control even when the fuses are out. However, on the Line Phases, voltage is measured right after fused, at the SP Fuse Base (16) terminal for load connection so that zero voltage will signal fault to the model for that particular line.

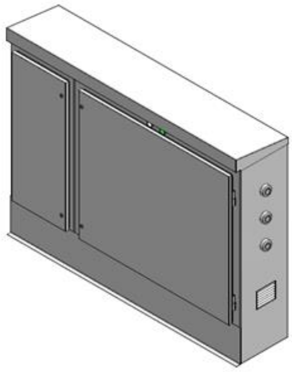


Figure 1: Isometric View of the Novel Electricity Distribution Pillar

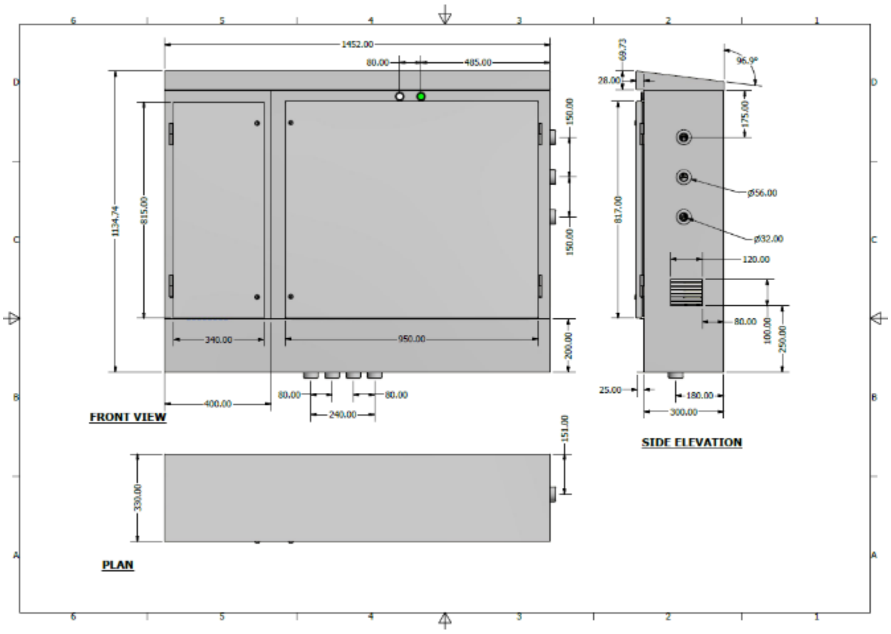
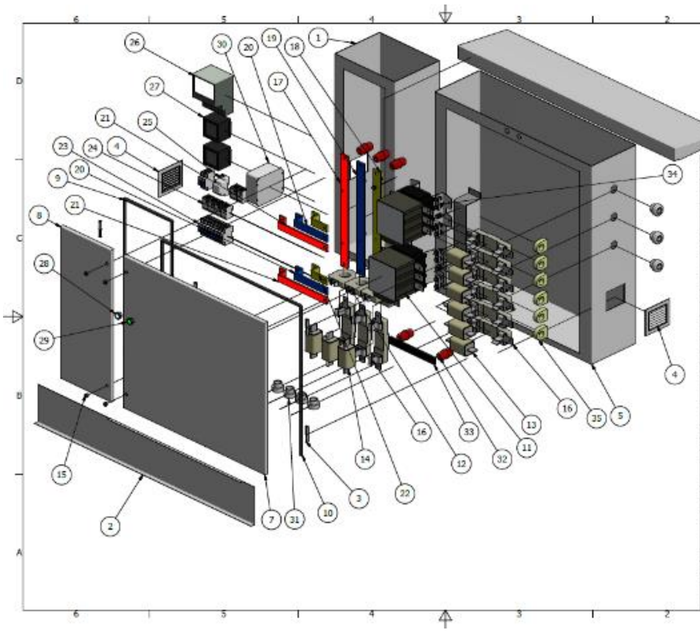


Figure 2: Orthographic View of the Novel Electricity Distribution Pill



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	Control Compactment
2	1	Front-Lower Cover
3	4	Hinge
4	2	Louver
5	1	Switching Compactment
6	1	Top Cover
7	1	Cover 1
8	1	Cover 2
9	1	Seal 1
10	1	Seal 2
11	2	400A Switchgear
12	3	Current Transformer
13	6	HRC Fuse Link (NT-400)
14	3	HRC Fuse Link (NT-800)
15	4	Key
16	9	SP Fuse Base
17	1	Phase Busbar- Red
18	1	Phase Busbar- Yellow
19	1	Phase Busbar- Blue
20	2	Phase Busbar 400A - Blue
21	2	Phase Busbar 400A - Red
22	2	Phase Busbar 400A - Yellow
23	10	6A Miniarture Circuit Breaker
24	6	10A Relay
25	1	12V DC Adapter
26	1	Analog Meter
27	2	Digital Meter
28	1	Connection Indicator
29	1	Power Indicator
30	1	Rowtina Smart Module
31	7	Cable Gland
32	5	Insulator Glens
33	1	Neutral Busbar
34	4	Connecting Bar
35	6	Line Current Transformer

Figure 3: Exploded View of the Novel Electricity Distribution Pillar

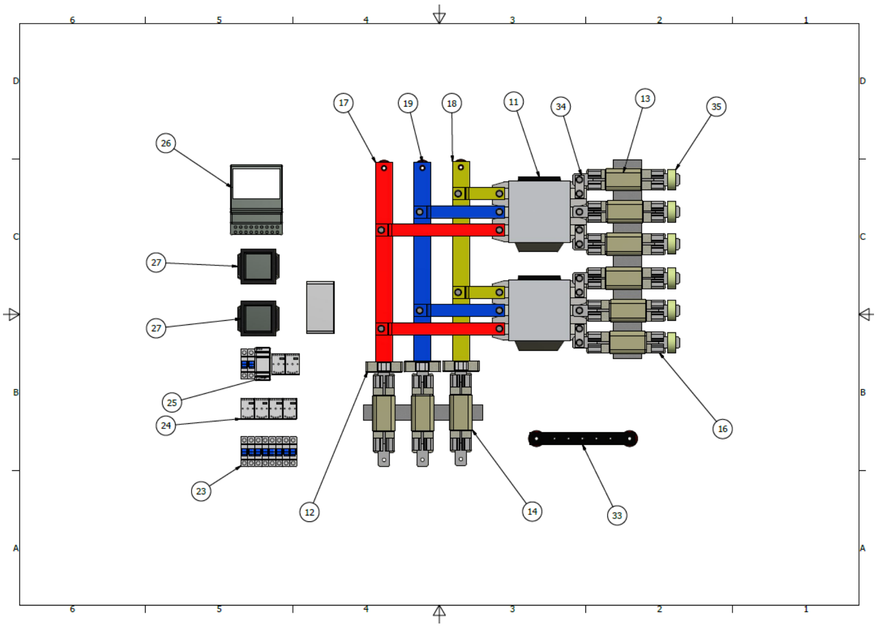


Figure 4: Front View of the Control Systems and Switching Gears

An Analog Meter (26) is used to calculate the total energy consumed by the station using the Current Transformers (12) mounted to each Phase Bus bar (17, 18 and 19). Whereas, the two Digital Meters (27) measure the lines voltage and current simultaneous. Each line voltage measured must pass through a 6A Miniature Circuit Breaker (23). Hence, all data computed by the Analog Meter (26) and the Digital Meters (27) are harvested by the Rowtina Smart Module (30) for further analysis. The Rowtina Smart Module is powered by a 12V DC Adapter (25) having a 3-Phase power supply system. Whereby, the power supplied to the Rowtina Smart Module (30) will not solely depend on a single phase, thus, when a phase is out, monitoring and communication will continue so are faults will be corded and reported promptly. Moreover, when the Rowtina Smart Module (30) is connected to the internet, the Communication Indicator (28) light comes on, while and immediately the internet service is no longer available, Communication Indicator (28) will go off. Similarly, when power is available in the Rowtina Switchgear Feeder Pillar, the Power Indicator (29) also comes on.

Meanwhile, the two 400A Switchgear (11) are actuated by the Rowtina Smart Module (30), through 10A Relays (24). Each 400A Switchgear (11) is connect to three 10A Relays (24), receiving power from each of the Phases. However, only one phase is used at a time to actuate the 400A Switchgear, which will be substituted by the module when the phase is out due to fuse failure. Although, 400A Switchgears are actuated independently, thus, ensuring that power is supplied to other lines before the fault is be rectified. Furthermore, Rowtina Smart Module (30) is designed to store and safe data. Whereas, data computed in the module can be sent to mobile phones via SMS to a configured mobile number, or to a web server database for visual representation. The module when powered, it takes 10 seconds to update it data from the EEPROM and synchronizes it current configuration from the server via ESP32 WiFi Module that is installed in it for web communication. Thus, enable the continuation of scheduled switching control and energy allocation. Similarly, a secondary backup timer powered by the RTC battery is added to the Rowtina Smart Module (30) mainboard which preserves the system clock and hardware state, in order to maintain scheduling even when online time isn't available immediately powered is restored to the grid.

In addition, the Rowtina Smart Module has a "Bypass mode", which allows the automatic control to be override. The Bypass mode is activated either when the internet service isn't available or when the Rowtina Smart Module (30) is faulty. However, the last schedule switching is maintained and returned to default at the end of the scheduled time while internet service is still not available for updates, whereas, when the Rowtina Smart Module (30) is faulty, the Bypass is manually set to put the system in constant default mode.

RESULTS

Novel Electricity Distribution Pillar is presented in Plate 6 and Plate 7. Plate 6 depicts the inside arrangement of the Feeder Pillar while Plate 7 is the picture when closed. The major components namely: an analog meter, digital voltmeter and ammeter, current transformers, 6A miniature circuit breakers, 12V DC adapter, Rowtina Smart Module, 6A relays, 400A contactors, control compartment and switching compartment are here arranged and installed into a box as Novel Electricity Distribution Pillar. It allocates energy to lines independently, sends and receives notifications both as SMS and/or on website, detect faults, report and isolate the faulty line until the fault is cleared before restoring the line's connections, as well as enable the control through SMS or website signals.

Plate 6: The inside of Novel Electricity Distribution Pillar (open)

Plate 7: Novel Electricity Distribution Pillar (closed).

CONCLUSION

The Department of Electrical/Electronic Engineering, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria in collaboration with the National Board for Technology Incubation (NBTI), Abuja, developed a novel Electricity Distribution Pillar from locally available materials. The device allocates energy and schedules switching time without constant removing and inserting of fuse link through a 400A switching device used as switchgear. This cuts out damaging of fuse link and fuse base and possibly arc flash / arc blast and flash over. In the case of emergency or on request, the system communicates with the operator by sending data through a Rowtina Smart Module to either a cell phone as SMS or web server via the internet in an HTTP format without the operator reaching the site for instant investigation. The introduction of Novel Electricity Distribution Pillar proposes to enhance operator safety and reduction in electrical hazards leading to smooth maintenance operations and better electricity supply in Nigeria.

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