POWER SWITCHING BRANCHING UNIT WITH COMMAND-CONTROL CAPABILITY

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Abstract: We have developed a command-control type of Power Switching Branching Unit (PSBU) for submarine cable applications. This paper describes the BU feature including components and key electrical circuits, performance of highly reliable LSI device, and re-configuration operation of electrical power feeding paths. In addition, the qualification test on the entire control system in actual power-feeding environment has been successfully demonstrated, using terminal equipment (power feeding equipment and command signal transmitter) and the BU.

1. INTRODUCTION

In accordance with rapid growth of internet services, the international communication demands among multiple countries are increasing significantly. Accordingly, many submarine cable systems today are being planned in mesh or multi-ring network providing direct point-to-point or simple ring connections. The attractive technical approaches in this area are optical signal branching, not per fiber but per wavelength band (i.e. optical add/drop multiplexing (OADM) system), and flexible power feeding path re-configuration during cable failures. The conventional BU has either a fixed power feeding path or a switchable path, which is controlled by predetermined current and potential. The newly developed PSBU, on the other hand, operates upon command signals from terminal stations, allowing power configuration to more complex submarine system with multiple landing stations.

2. PSBU FEATURE

Table 1 and Figure 1 show the main parameters of PSBU and the external view of its inner unit respectively.
The inner unit is composed of optical circuits (including fiber couplers and optical filters which extract optical command signals), command control circuits (including an LSI device which receives/decodes command signals and controls relay drive circuits), vacuum relay drive circuits and surge protection circuits. The mechanical design of this PSBU is the same as a conventional BU. We can apply the conventional loading and laying methods and procedures to the new BU.

Table 1: Major Parameters of PSBU

Parameters	Design value
Number of fiber pair	max 8 fiber pairs
Loss (without EDFAs)	<2dB (fiber branch type) <9dB (OADM type)
Optical command control port	max 4ch
Dynamic range of optical input power (control functions are available)	>20dB
Wavelength of optical command signal	depend on system configuration
EDFAs	as an option
Minimum line current (control functions are available)	500mA

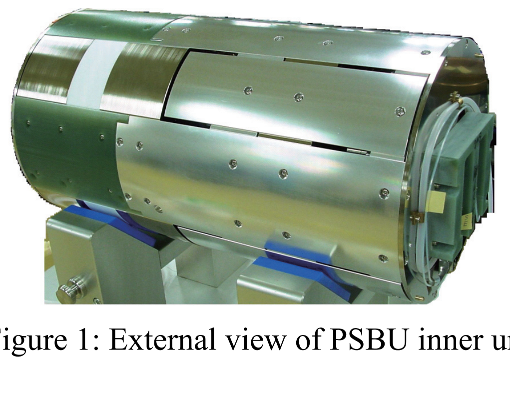

Figure 1: External view of PSBU inner unit

The PSBU is controlled by command signals transmitted over dedicated wavelength from terminal equipment. Such optical command signals are extracted with an optical filter. PSBU has 4 command control ports for connection to transmission fiber lines. In case a cable failure occurs, the terminal equipment connected to remaining cables can control the BU. Command receiving circuits have an electrical band-pass filer (BPF) in order to extract a carrier frequency of command signals. To get better SNR, Q of BPF is approximately 30. Thanks to the electrical amplifiers with an automatic gain control function, the minimum optical sensitivity of command signals is less than -35dBm and the dynamic range is over 20dB with the expected minimum SNR of 8dB/0.2nm in WDM submarine cable system. Since the minimum line current for which control functions are available is 500mA, PSBU can be controlled even with reduced system line current.

As an option, the PSBU can accommodate several optical modules, such as optical couplers and optical add/drop filters, so that it can be applied to the OADM system. EDFAs can also be mounted. The EDFAs are useful to compensate optical signal power, if cable failures occur and some signals are lost in the OADM system.

2.1 LSI device

In order to realize command control functions, we have developed a new LSI device with high reliability. The LSI is made using silicon bipolar technology. The LSI device has several functions such as command receiving, demodulation, decoding and relay control. The LSI design parameters are shown in Table 2.

The LSI makes some control actions, whenever the address code in command signals corresponds to the pre-assigned BU address. To prevent miss-operations due to bit errors, the LSI can operate only when the 2 sets of command lines are identical with each other.

Table 2: LSI Design Parameters

Parameter	Design value
Input port	4ch
Carrier frequency	150kHz
Modulation format	ASK
Signal format	PWM
BU address	9bit
Relay control	max 9ch
Level control	max 2ch 4level
Monitor	A/D converter with 4ch monitor port and temperature monitor

The LSI is designed not only for relay control of PSBU but also for other control functions such as level control for an active gain tilt equalizer.
This LSI is ready for commercial use, as the reliability and qualification test have been completed.

2.2 POWER CIRCUIT IN PSBU

A simplified schematic diagram of the power circuit in PSBU is shown in Figure 2.

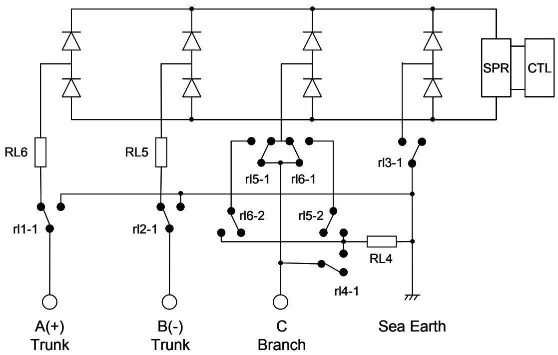

Figure 2: Power circuit of PSBU

At first, initial power up operation is carried out as follows. The trunk current between A and B is powered up. Branch C is automatically isolated from the trunk path and connected to Sea Earth. Finally, the branch current between C and Sea Earth is powered up. If all current of trunk and branch is powered down, the power circuits go back to the initial state.

Secondly, when a cable failure happens on the trunk B side, power re-configuration from normal power feeding configuration is implemented as follows. “Relay3 ON” command is sent from terminal equipment, and then the BU whose address corresponds with the command connects to Sea Earth. Next, "Relay2 ON" command is sent, leg-B is connected to Sea Earth and A-C connection is established. Finally, Sending "Relay3 OFF" command isolates A-C path from B.

3. POWER CONFIGRATIONS IN PSBU

Thanks to the command control functions, the PSBU can have five power configurations. Each power configuration is summarized in Fig. 3.

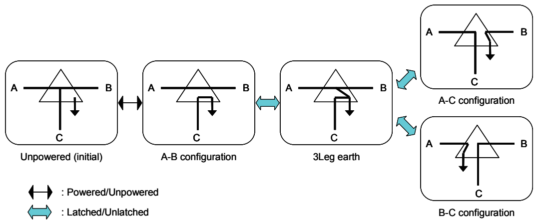

Figure 3: Power configurations in PSBU

Initial unpowered configuration is that 3-legs (A/B/C) are connected to one another and isolated from Sea Earth. Simple trunk A & B powering up operation establishes A-B connection. Some command operations offer A-C or B-C connection. A-C and B-C configurations can be maintained even if the system power goes down when cable failures occur. Consequently, even if unexpected power down occurs during cable repair work, the cable repair work can be performed without any concern about sudden power configuration change.

4. SYSTEM DEMONSTRATION

The entire control sequences with an actual power feeding environment have been successfully demonstrated. Experimental setup is shown in Figure 4. Three power feeding equipment (PFE) and three dummy cable lines are connected to each PSBU tails.

In any cable faults, the PSBU can be controlled for the power re-configuration, which is one of the advantages over the conventional BU.

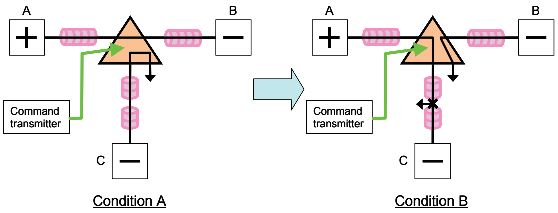

Figure 4: An example of system test configuration

For example, a power re-configuration was performed assuming a shunt fault on a branch cable. Initially the trunk and branch current is powered up (condition A). When a shunt fault occurs at the middle of leg-C cable, the current between BU and the shunt fault point becomes zero. In this failure case, required command sets for power re-configuration are sent from a terminal A and B. A-B connection changes to A-shunt / B-BU(Sea Earth) / C-shunt connections successfully (condition B). Then, in the case of shunt fault, all communication line can be restored.

5. CONCLUSION

We have developed a command-controlled Power Switching Branching Unit. The overall BU is ready for commercial use, as their reliability and qualification tests have been successfully completed. The command controlled PSBU will enable easy power re-configuration, and rapidly recovers submarine networks from potential cable failures.

6. REFERENCES

C.E.Little, et al
"Electrical Power Switching and Sea Earth Design for Submerged Branching Units", SubOptic 2001, Kyoto Japan, Paper T4.2.5

A.Cordier, et al,
"System Powering – How to Make Operation Easier", SubOptic 2004, Monaco, Paper Tu2.2

