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ACTIVE FLYING LEADS: TRANSFORMATIVE TECHNOLOGY FOR SUBSEA FIELDS

Michael Greene[1], Howard Painter [2]

Abstract

Modern and emerging sensors and systems now demand greater data transmission capability. The data is used for a myriad of applications, from monitoring the health of a pipeline in an oil and gas field, to detecting seismic activity on the seabed, or to research climate change, among many others. As sensors have become more sensitive and reliable, interconnect systems have also evolved. The need for enhanced reliability and the ability to collect complete data and confidently measure reliability is ever increasing. Data provides a window into a world we can't visually see, and the trend continues to point to gathering more and more data as sensors and systems develop further into longer step-outs and higher bandwidth. Subsea networks will in turn require modular connectivity using interconnect systems capable of supporting this high bandwidth availability. New technology is being introduced into the subsea space. This new technology is able to gather more data and respond in real time to changing conditions. With the increased use of Ethernet and CAN Bus, length restriction have caused problems. Conventional thinking needs to be changed and new technologies introduced. By miniaturizing and simplifying components, complexity and cost can be improved.

Traditionally, flying leads (or jumpers) have been considered a passive element in subsea infrastructure, meaning that power and data move through the system without interference or modification. The introduction of Active Flying Leads and the evolution of subsea fiber optic connectors provide a platform to solve future challenges in subsea data communication. Identified as Active Flying Leads (AFL), this technology allows allow for the use of electronics integrated into a connector or in-line with the jumper, and in some cases, converting from different methods of communication that the equipment utilizes, transforming the Flying Lead into an active component in a subsea data transmission system. The AFL platform consists of functional electronics housed within a qualified atmospheric chamber that can be placed in line with a pressure-balanced, oil-filled (PBOF) hose. Glass-to-metal sealed penetrators provide fail-safe pressure barriers within the chamber for reliable performance under the extreme pressures found in deep water subsea fields. The Active Flying Leads can also be used to extend communication to lengths that were previously not possible. The AFLs are retrievable with an ROV for maintenance and upgrades if necessary; allowing for further operational cost savings. They can also be used to get sensitive equipment further from the shore or in more remote areas than previous technology allowed.

1. Introduction

In 2011, feedback from subsea oil field operators indicated that the current subsea length limitations were quickly going to become potential issues as subsea fields continued to evolve. In response, the New Product Development team at Teledyne Oil & Gas launched a technology project to examine current subsea data and power transmission product offerings, concluding that we could provide almost any Ethernet length imaginable if the copper signal was converted to fiber. After some initial research and development, we created the first Active Flying Lead (AFL) prototype. At that time we called the development Extended Ethernet – 10K or E²FL-10k. (Figure 1.) We then created a prototype and tested the concept for functionality and the ability to withstand noise from AC and DC voltage as well as pressure. After completion of the first concept, we then studied the potential technology gaps surrounding

[1] Technology Manager – Ethernet and Integrated Electronics – TELEDYNE OIL & GAS
[2] VP Business Development, Latin America - TELEDYNE OIL & GAS

the use of subsea Ethernet, and found that the initial AFL concept was in fact feasible; however, the E²FL-10K may not be a universally practical solution for all field layouts.

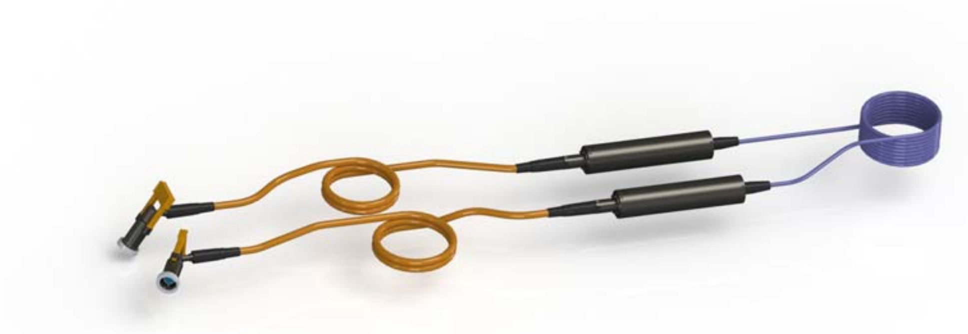

Figure 1. Initial prototype of the E²FL-10K

2. Longer Length Ethernet Solutions

To develop a more-widely applicable Ethernet solution that increased length without adding cost, we studied the IEEE 802.3 specification and determined that we had room for optimization without adding electronics to the flying lead. The first area of focus for improvement was the connector pin-out and cable termination. These improvements added little to no cost to the overall product. The next big improvement came from designing a custom Ethernet cable that was to be used in air and an oil-filled environment. The new cable increased the allowable length from 60 meters to 100 meters, without adding electronics. The cost of the custom cable is slightly higher than that of the terrestrial bulk cable that is traditionally used in these applications, but the improvement in performance and length easily justifies the increased price. As volume increases, it is likely that this cable can become less expensive as well. This was by far one of the biggest improvements per cost, and has served as the foundation for subsequent innovations.

2.1. Increasing Length Using Repeaters

After reaching the maximum allowable distance without adding electronics, we investigated methods to increase length without switching to fiber optics. This project resulted in the development of the Extended Ethernet Flying Lead -300 or E²FL-300, and was considered the first official Active Flying Lead or AFL product in the family. This technology is designed to be a tool to optimize subsea field layout and design. The following example will illustrate how this can potentially transform the architecture of a field. For this simulation, let’s propose that we have a field which requires a Multi-Phase Flow Meter (MPFM) that is 175 meters from the nearest controls module (Figure 2).

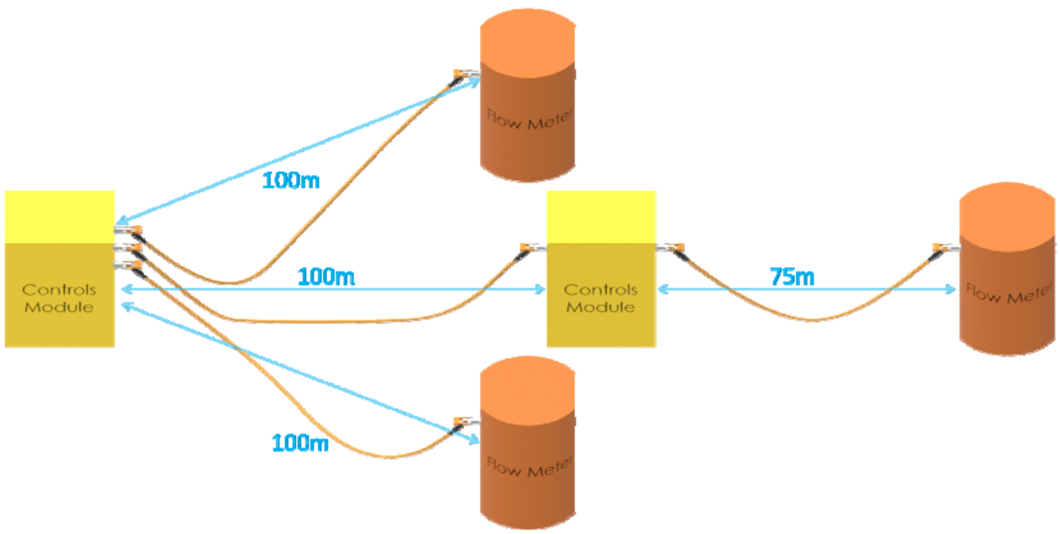

Figure 2. Field with Multi-Phase Flow Meter and additional controls module.

Most current MPFMs are designed for use with Ethernet protocol, due to the large amount of data gathered from the device. Copper Ethernet cables are limited to only 100 meters. The prevailing options would be to: (1) deploy another control module just to service one MPFM, which would be a sizeable expense, or (2), have a new MPFM developed using a different protocol which could handle the distance and data rate. The second option may initially seem preferable to the first. The new MPFM would require additional development cost due to qualification but would have then resulted in a ready solution. However, the controls pod would have to be modified to accommodate the custom output, resulting in a unique part, which would then require a spare. These costs can add heavily to a total project cost. In an ideal situation, you would prefer to have one standard for all cases. Now let's compare the repeater solution, shown in Figure 3. With the AFL, which costs slightly more than the typical flying lead without electronics, you can keep the original equipment standard. This has the effect of reducing any development cost, and in turn, reducing installation cost and capital equipment cost.

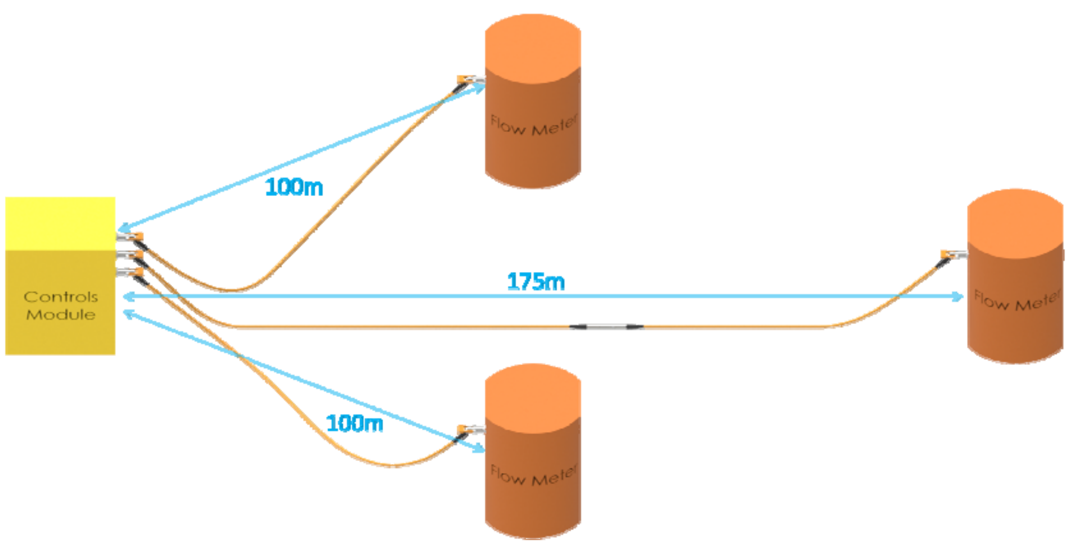

Figure 3. Field with Multi-Phase Flow Meter with repeater

2.2. Increasing Length Using Optical Conversion

The next AFL solution developed was the Electrical/Optical Flying Lead or EOFL. This innovative technology converts a fiber optic signal to copper Ethernet. This product has the greatest potential to impact traditional field layouts. The EOFL converts a fiber optic signal through a hybrid fiber optic wet-mate connector, producing an electrical Ethernet signal through a 12-way electrical connector on the other end. The conversion from optical to electrical is accomplished in a compact 1-atmosphere internal pressure chamber, as shown in Figure (4).

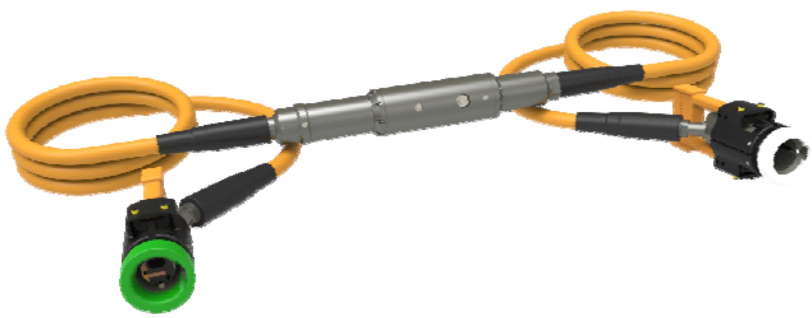

Figure 4. Electrical/Optical Flying Lead (EOFL)

Modern and emerging sensors and systems now demand greater data transmission capability. The data is used for a myriad of applications, from monitoring the health of a pipeline in an oil and gas field, to detecting seismic activity on the seabed, or to research climate change, among many others. In certain fields, this option allows for many improvements over the previous methods. To illustrate this concept, we will examine a fictional subsea field as shown in Figure (5).

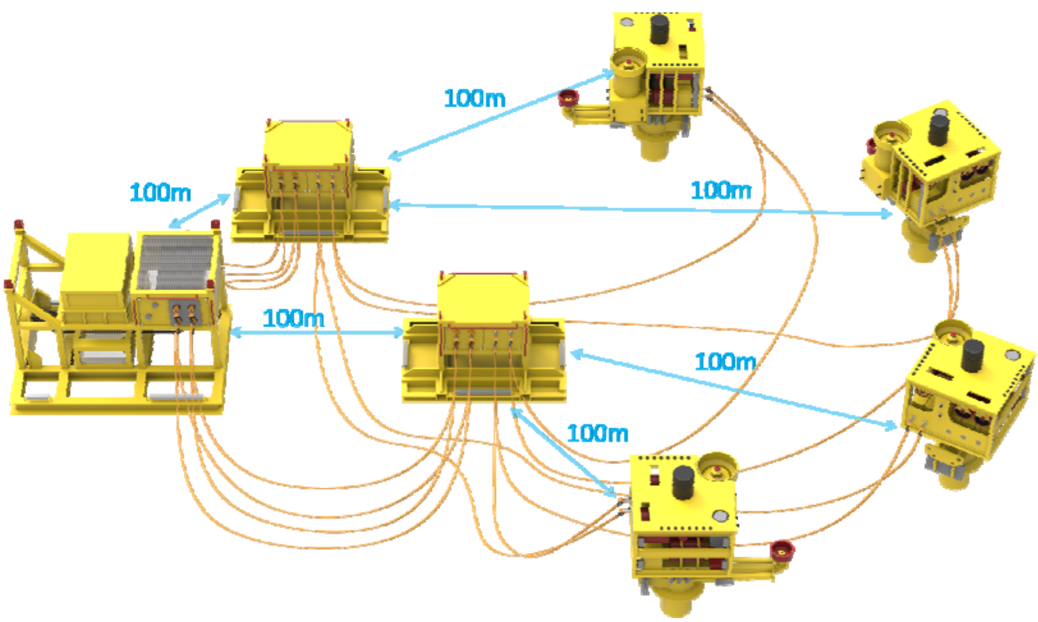

Figure 5. Subsea layout

In this example, communication signal and power comes in to the Umbilical Termination Assembly (UTA) from the surface. It is then distributed to the router module, of which there are two for every six wells for redundancy. The router modules are then connected to each controls tree. If the distance between the router and the control tree is greater than 100 meters, we run in to the same scenario as the Ethernet repeater application example and would need to use the E²fl-300 to accommodate the maximum length. With the introduction of the EOFL, it is possible to remove both subsea router modules from the field, as illustrated in Figure (6).

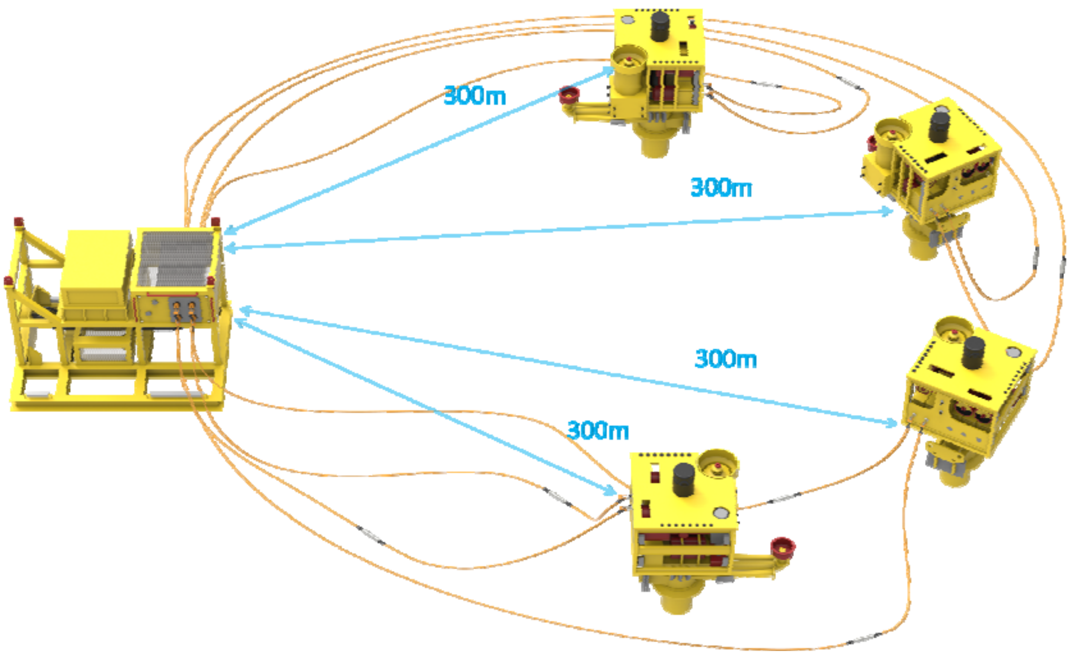

Figure 6. Subsea layout using Active Flying Leads

3. Benefits of Using an Electrical/Optical Flying Lead

This new product may be used in place of more complex equipment such as secondary nodes and junction boxes or distribution manifolds, allowing a simplified infrastructure at reduced cost and risk. The use of fiber in the EOFL removes many length limitations that would be seen with an all-copper solution. Now the UTA is able to connect directly to the controls tree via the flying lead, eliminating the need for additional equipment. Additionally, due to the multiple length options for the EOFL, lengths can be selected to reduce the number of spares required, and installation can be completed cleanly and sized correctly for the field.

One of the main features of the EOFL is the use of SFP’s on the circuit board. SFP stands for Small Form-Factor Pluggable, and is an industry-standardized optical to electrical converter that provides great flexibility. They come in single or two fiber options. The wavelength and power of the transmitter and receiver can be altered by changing SFP’s. The power rating is generally correlated to a certain distance: 40km, 80km, or 120km.

4. Active Flying Leads Can Transform a Subsea Network

The AFLs are retrievable with an ROV for maintenance and upgrades if necessary; allowing for further operational cost savings. They can also be used to get sensitive equipment further from the shore or in more remote areas than previous technology allowed. As sensors have become more sensitive and reliable, interconnect systems have also evolved. The need for enhanced reliability and the ability to collect complete data and confidently measure reliability is ever increasing.

Data provides a window into a world we can't visually see, and the trend continues to point to gathering more and more data as sensors and systems develop further into longer step-outs and higher bandwidth. Subsea networks will in turn require modular connectivity using interconnect systems capable of supporting this high bandwidth availability. This new technology is able to gather more data and respond in real time to changing conditions, providing operators with both the data they require and the reliability that assures operational performance over the life of the field.

7. Acknowledgements

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8. References

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