Advanced Communications Payload Architecture Considering Dual-Channel Combinations

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Classical high-capacity communications payloads commonly serve many individual channels. They generally rely on a channelized approach where the individual communication channels are separated by the input multiplexer (IMUX) preceding the high power amplifiers (usually traveling wave tube amplifiers (TWTAs)) as illustrated in Fig. 1. Each channel is dedicated to one amplifier path, passing the redundancy switching matrices preceding and following the amplifier section. The amplified channels are then combined by assigned output multiplexers (OMUXes) to serve all channels of a dedicated transmit antenna/service area. Obviously, these payloads require many TWTAs with complex coaxial and waveguide harnesses, respectively, for the interconnection with the redundancy switching matrices preceding and following the amplifiers.

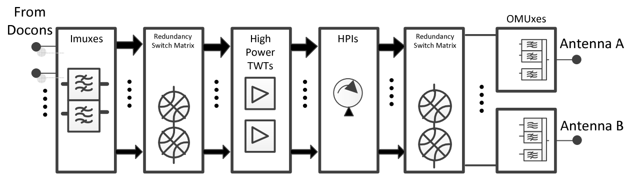

Fig.1: Traditional architecture of DTH applications.

This paper provides a novel dual-channel approach to reduce the number of TWTAs along with associated equipment (e.g. electric power conditioner (EPC) and high power isolator (HPI)) in classical communications payload architectures for DTH applications. The concept considers simultaneous operation of two channels using one TWTA that provides increased power to satisfy the same EIRP demands as the operation of one TWTA per channel. This is similar to high throughput satellite (HTS) applications. However, in HTS applications, two contiguous channels are served by one TWTA, and are consecutively separated by a de-multiplexer (DEMUX) and directed to different antenna feeds (service areas). Due to the inherent application of the HTS systems, a TWTA back-off is always required (between 3 and 6 dB) to accommodate the applied high-order modulation schemes (16APSK, 32APSK, etc.) and the link budget characteristics.
In contrast to this, the proposed approach, considers channels with a frequency separation of >500MHz. This avoids strong inter-channel interference, allowing the use of a small back-off and hence operation at a higher TWTA efficiency. Moreover, the channels can easily be separated by compact high-performance diplexers. The operated 'dual' channels may be dedicated to the same or different service area(s) so that, following the diplexer, they are connected to the same or different OMUX. This approach yields a significant reduction in the number of TWTAs, the required redundancy equipment (switches and associated harnesses), and the payload complexity. This leads to substantial cost savings when compared with current communications payload realizations.

A channel frequency scheme for the application of the new approach is depicted in Fig. 2. Channels with a frequency distance of more than 500MHz that are dedicated to the same service area or different ones (i.e., the same OMUX or different OMUXes) are considered for the combination. They may have identical or different bandwidths. A block diagram of the implementation is shown in Fig. 3. Generally, the individual channel signals are separated by IMUXes that follow the down converters. For the combination of the dual channel pairs the outputs of the dedicated IMUX filters can be easily combined with a circulator. The dual channel signals are handled in the same way as single channels, i.e. they are routed through the low power redundancy switching matrix between IMUX and transmit amplifier section, the assigned high power amplifier and the output redundancy switching section.

Consecutively, the amplified dual channel signals are separated by high performance diplexers. Due to the large frequency distance of the channels, generic diplexer designs are considered for several dual channel combinations that provide typically more than 40dB isolation, 30dB return loss and insertion loss less than <<0.15dB. (Similar diplexers have been applied in antenna feed systems for the separation of receive and transmit bands.) The extra insertion loss of the diplexers is partially compensated by the lower complexity allowing shorter waveguide interconnections.

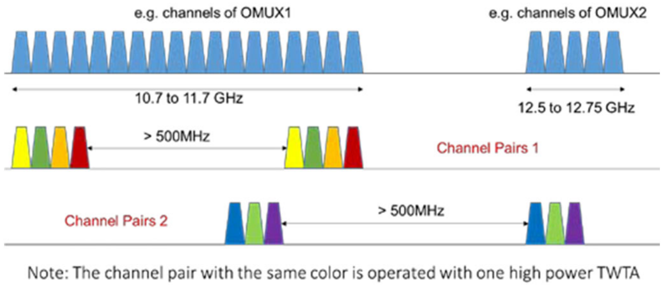

Fig. 2: Channel frequency scheme for dual channel concept

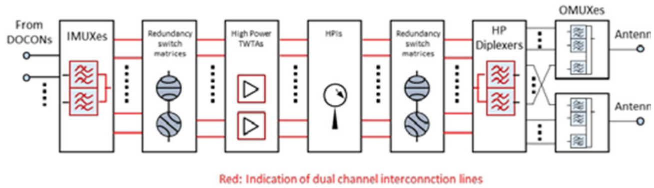

Fig. 3: Block diagram for dual channel operation

The use of TWTAs for the amplification of two contiguous channels has been established for HTS applications [1] taking into account the evaluation of number of carriers and modulation schemes. According to the system demands for the present configuration, several possibilities have been evaluated. The application goal here is the transmission of DTH services, which commonly employ low order modulation schemes. Thus, the TWTAs can be operated with a reduced back-off to satisfy the system transmission demands which accommodates the performance of the two channels that are comparable with the classical approach using TWTAs without back-off for a single channel [2]. The large distance of the two routed channels/bands allows convenient control of occurring spurious signal like intermodulation that is not falling into the neighbor channel and other spurious signals that may appear. These are easily suppressed by the used separating diplexer or by other filters (e.g. OMUX) of the output section that are generally necessary for this kind of payload.

The extent of the advantage of the new concept depends on the number of channels that could be conveniently combined and served by common TWTAs. For typical payload architectures involving around 60 operated channels, more than half the number of channels may be considered in the introduced manner in dual channel operation. Thus, only 45 operational TWTAs (30 standard and 15 high power types) are required instead of the 60 standard TWTAs in the classical payload approach. This also leads to a reduction in the associated equipment (amplifier, EPC, HPI, redundancy switch matrices) and harnesses by more than 25%. The reduction of the TWTAs with the associated equipment will not only yield significant cost savings and reduction of overall payload mass and complexity but it also allows the optimal accommodation of the equipment in view of thermal subsystem aspects, which may lead to additional cost savings. Moreover, due to the reduced equipment, there may be extra space and capacity on the satellite for an additional hosted payload.

<u>References:</u>

[1] Accurate Characterization of TWTA Distortion in Multicarrier Operation by Means of a Correlation-Based Method - IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 56, NO. 5, MAY 2009.

[2] Unpublished communication with TWT provider.