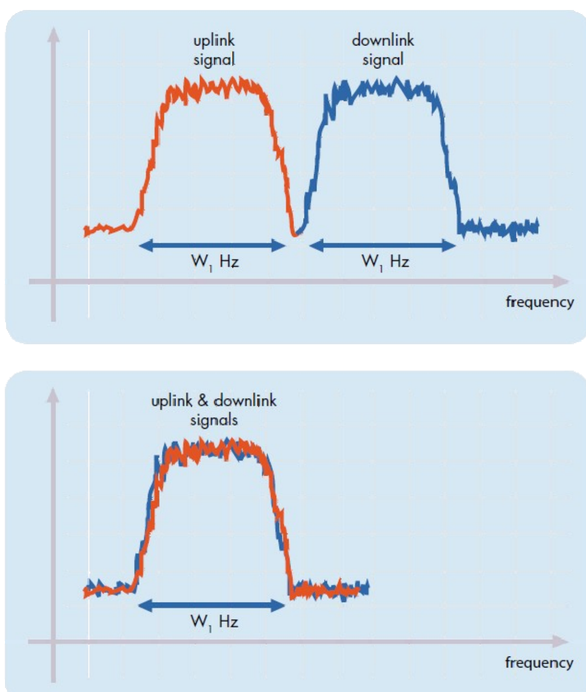
Application Note
Paired Carrier Multiple Access

Paired Carrier Multiple Access (PCMA), the latest satellite spectrum-saving feature from Paradise Datacom is designed to provide satellite-based system operators with a way to greatly increase their utilization-efficiency of transponder spectrum to reduce operating costs or increase the amount of information that can be transmitted over a transponder. The degree of savings depends on a number of factors including satellite performance and link design as it relates to the ratio of transponder power and bandwidth required to accommodate the traffic. System design considerations are expressed later in this document.

PCMA, a patented technology developed by ViaSat, uses an adaptive, self-interference cancellation technique to allow transmit and receive carriers of a duplex link to be superimposed on to one another to achieve space segment savings of up to 50% (see Figure 1 below). A sample of the transmit signal is routed to the cancellation circuits where it is modified to emulate propagation effects and then used to eliminate the transmit carrier signature from the composite local + distant signals being received from the satellite.



Typical SCPC satellite link with separate frequency slots for transmit and receive carriers.

Using Paired Carrier, uplink and downlink carriers are superimposed, allowing savings of up to 50% on space segment.

Figure 1: Overlapping of carriers into common spectral footprint.

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Point-to-Point Applications

For single-carrier point-to-point applications, Paradise Datacom modems with embedded PCMA (as depicted in Figure 2) can be placed on both ends of the link. This includes Evolution, Vision and Quantum-series modems. For customers with existing links and no desire to replace modems, PCMA can be provided in the form of outboard PCMA-70 installed in the IF chain between the modem(s) and RF converters. The diagram of Figure 2 shows a simplified example of a Paradise Datacom satellite modem equipped with internal PCMA. When using the embedded PCMA, the adjustable parameters of the PCMA circuits are addressed by way of the modem's front panel controls.

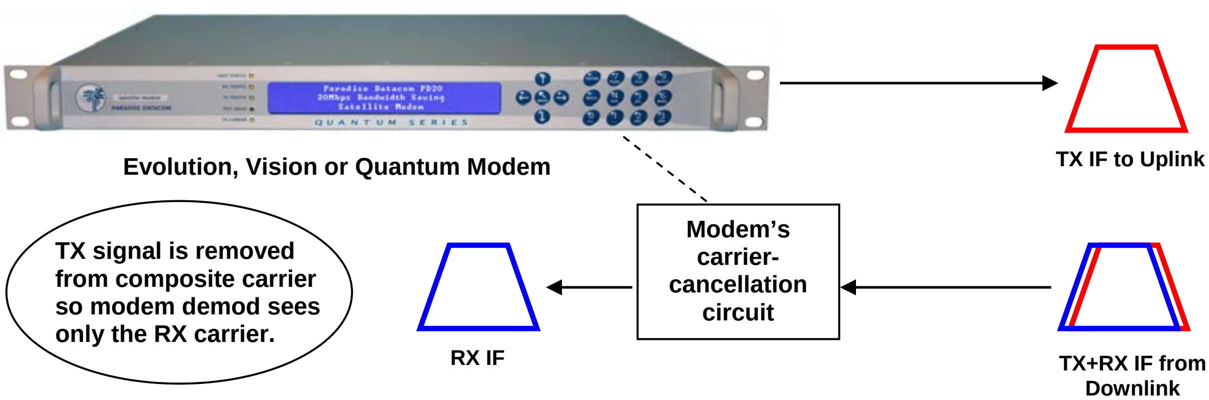


Figure 2: Point-to-Point SCPC Terminal (two required)

For ***point-to-point*** links, maintaining similar carrier power levels minimizes Eb/No degradation with the effect being less significant for lower order modulation schemes. For example, two TPC/QPSK carriers with a 10 dB power ratio will experience a maximum degradation of ~0.4 dB whereas changing the modulation to TPC/8 PSK increases degradation by ~0.5 dB.

Point-to-Multipoint Applications

The spectrum savings benefit from the PCMA-70 is equally applicable to many VSAT or point-to-multipoint system architectures. In the example depicted in Figure 3, multiple return signals are being transmitted within the larger outbound carrier's spectral foot print. A single modulator generates an outbound carrier sending information to four remote sites. The remotes generate lower data-rate return carriers that are placed within the same transponder spectrum being occupied by the larger outbound carrier. The composite TX + RX carriers received at the hub are routed through the PCMA-70 where the outbound carrier originated at the hub is removed leaving only the four carriers received from the remotes.

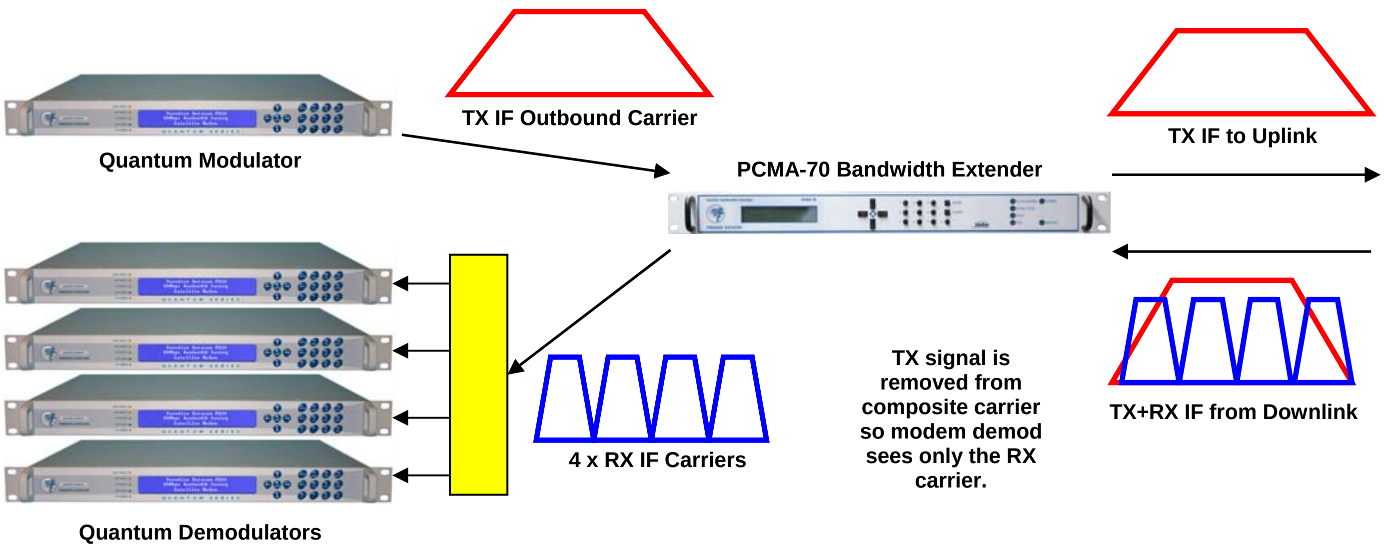


Figure 3: Point-to-Multipoint Hub

In ***point-to-multipoint*** applications, maximum savings is achieved when the return carriers will fit within the spectral footprint of the hub's outbound carrier. The hub carrier level should be a minimum of 10 dB above the level of the return carriers to insure that the remote sites receive the outbound carrier with sufficient carrier-to-interference (C/I). No cancellation is required at the remotes since the return carriers will be treated as interference or system noise in relationship to the larger outbound carrier. The satellite link analysis typically includes a small amount of additional system loss to compensate for this effect. Since in many STAR and VSAT network architectures the hub-to-remote ratio can be high, the symbol-rate asymmetries between the outbound and inbound signals must be accommodated by the signal canceller. Asymmetries of up to 20:1 have been recorded and higher asymmetries are certainly possible.

It is important to note that the system architecture described in Figure 3 does not require carrier cancellation at the remote sites. Consequently, a single PCMA-70 at the hub station is all that is required. This can result in significant savings over embedded technology for point-to-multipoint topologies.

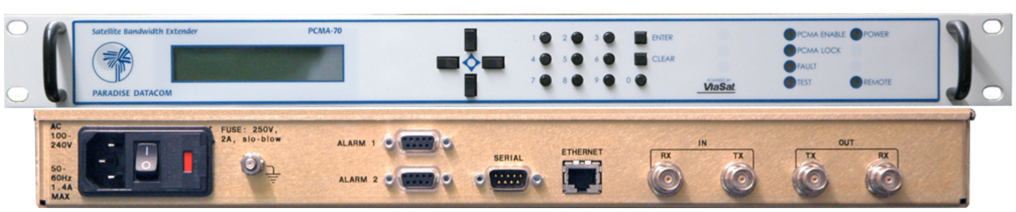
Embedded vs. Outboard PCMA

<u>Embedded PCMA</u>

Paradise Datacom Quantum Series Modem

The embedded version of PCMA can be purchased as a field upgrade for any Paradise Datacom modem including Evolution, Vision and Quantum modems shipped after January 2009. Modems shipped prior to January 2009 can be retrofitted at one of Paradise Datacom's factories in US or UK. Currently, modems can be ordered with the internal PCMA hardware installed at the factory prior to shipment allowing the feature to be installed on site at a future date.

<u>Outboard PCMA</u>



PCMA-70 Bandwidth Extender

For applications where PCMA bandwidth optimization is required outside of the satellite modem(s), PCMA-70 is housed in a 1-RU (1.75") chassis and is available in a number of band-pass configurations including 2, 5, 10, 20 and 36 MHz. Redundancy switching is also available.

System Design Considerations for PCMA

The extent of savings that can be realized by implementing PCMA is dependant upon a number of factors that should be confirmed by performing a thorough satellite link analysis. For optimum performance, the following conditions should be met:

- Links must be bandwidth-limited as opposed to power limited. For maximum benefit, required XPDR power should be half of required bandwidth so that superimposed carriers are balanced.
- Each site in the network must be able to receive its own carrier (i.e. no cross-strapped transponders)
- Only signals with an occupied bandwidth of 150 kHz to 36 MHz will work with PCMA.
- Automatic Uplink Power Control (AUPC) is recommended to maintain power levels during rain-fade conditions since maintaining the carrier levels to +/- 5 dB limits Eb/No degradation to ~0.2 dB.
- Power asymmetry between carriers should be no more than 10 dB.
- For existing links, signal power must be increased 0.15 - 0.5 dB depending on relative carrier power ratio.

For cases in which the system architecture has a power limitation component preventing the ability to achieve maximum benefit from PCMA, changes in ground station components and settings can provide the additional power necessary. These changes include:

- Increasing antenna size at one or both ends of the link
- Improving coding gain i.e. changing from Viterbi to TPC/LDPC or modulation/FEC rate i.e. 8PSK 7/8 to QPSK ¾ therefore requiring less power to achieve a target bit error rate (BER).
- Using a higher quality LNA/LNB
- Switching to a higher power transponder

Note:

QUANTUM and VISION modems with PCMA provide the added benefit of DVB-S2 technology for an even greater degree of spectral efficiency. DVB-S2 alone can increase efficiency over Turbo Product Code by 15% and DVB-S by 30%.

Please contact Paradise Datacom for inquiries regarding PCMA technology and how it may be applied to specific earth station architectures to reduce operating costs. Having decades of total system design experience, our system engineers will perform an in-depth satellite link analysis to identify the potential benefits of implementing this cutting-edge technology.