# Redundancy Schemes for Frequency Converters

by Dr. Andrea Franz, A.G. Franz LLC

Football season is just around the corner and fans are gearing up for tailgate parties at live events, or at home with friends to watch their favorite teams in front of their TVs. Most of these transmissions from stadium to consumer involve a satellite link somewhere in the chain and therefore frequency conversions from Baseband to X-, C-, Ku- and Ka-Band, depending on the satellite segment. So what happens when for some unlucky reason a frequency converter breaks, i.e. no longer supports the delivery of the video to the fans' TV? Satellite earth-station operators approach this very real failure scenario in different ways – from hardly noticable to the consumer to a complete outage and black screen for hours. The following paper describes these different redundancy schemes in greater detail.

## Agile Frequency-Converters

At satellite earth stations numerous satellite transponder signals are being directly received from the satellites and downconverted for further processing at intermediate frequencie or they are upconvertered from the intermediate frequencies to be sent to the satellites. Typical applications include X-, C-, Ku- and Ka-Band satellite payloads.

## Redundancy

In order to ensure highest reliability and availability for their satellite customers, earth station operators apply redundancy schemes for the up- and down-link equipment chains. Depending upon the system deployment reliability and availability requirements, operational complexity as well as budget and space constraints, different redundancy configurations are deployed. Each configuration requires additional equipment or component parts to implement the chosen redundancy scheme.

In the following discussion the term "detected fault" is defined as either a failure of the unit, or a catastrophic (power) failure.

## 1-for-1 Passive Redundancy

This approach is the simplest and least expensive implementation. The configuration relies entirely on the internal control capability of the converters: any two identical converters will operate as a 1-for-1 passive redundant pair, with no other equipment except for a single interconnecting CANBUS® control lead, two power splitters /combiners and RF cables to connect the units in parallel. (see Fig.1)

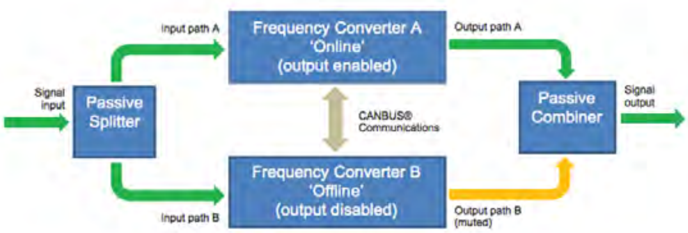


Fig.1: 1-for-1 Passive Redundancy

Both converters operate continuously, performing their conversion function on the incoming signals, but only one unit enables its output. Each converter continually provides status to the other unit's 1-for-1 control logic. There is no pre-assigned master and slave unit. Change-overs are minimized, i.e. a unit disabled due to a reported fault, will remain disabled even if it returns to the non-alarm state.

In the event of a catastrophic fault, such as a power supply disconnection etc., the control circuitry (which is distributed between the two units) will automatically disable the faulty unit and enable the operational unit.

The biggest disadvantage of such a configuration is that it includes passive two-way splitters & combiners, each with a theoretical 3dB loss, so an associated overall loss of typically 8dB (does not include converter gain) can be expected through the system which will typically be higher than on a traditional co-axial 'switched redundant' system, resulting in signal loss that may require additional gain to compensate.

## 1-for-1 Redundancy with an External Switching Unit

Any two identical converters will operate as a 1-for-1 redundant pair, without the need for an additional controller. All that is required is a switch unit with all necessary

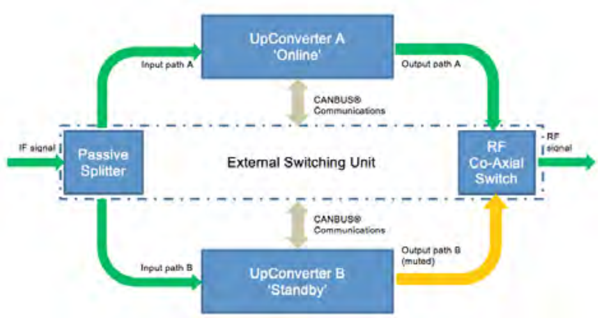


Fig.2: 1-for-1 Redundant Upconverter System with External Switching Unit

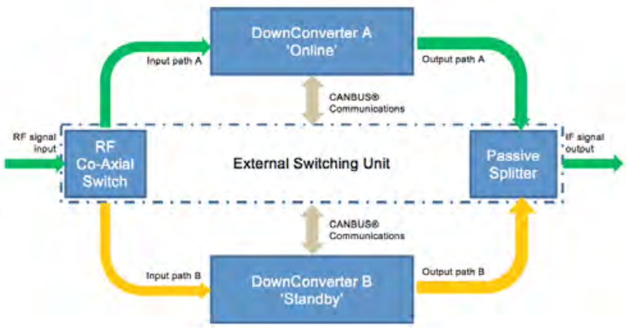


**Fig.3: 1-for-1 Redundant Downconverter System with External Switching Unit**

interface cabling. UpConverter systems require a unit comprising an input IF splitter and an RF coaxial switch to switch the output. (see Fig.2) DownConverter systems require a unit comprising an input RF coaxial switch and an IF combiner at the output. (see Fig.3)

Both converters monitor the alarm status of each other and control the output coaxial switch, ensuring that the online converter is always connected to the output. If the online converter develops an alarm condition, the standby converter will assume master control and initiate switching, routing itself to the output.

Change-overs are minimized, i.e. a unit taken off line due to an alarm, will remain off- line even if it returns to the non-alarm state. If it does return to the non-alarm state then it will act as the standby unit.

Although an external unit containing the switching and splitting/ combining parts is required, this is still a very cost effective solution as it utilizes the Converter control system. It is very simple to set up and the biggest advantage of this hybrid system of passive combiners/ splitters and active switches is that the loss is reduced to typically 5dB (does not include converter gain) through the system.

**Peak Communications offer these flexible redundancy schemes described in this article for their P7000 series converters, a next generation fully synthesized combined L-Band Up and DownConverters. The P7000 converters provide a very efficient solution for systems requiring an IF interface at 70MHz 18MHz or 140MHz 36MHz. Depending on the system requirements and budgets these systems can be tailored to every applications' needs.**

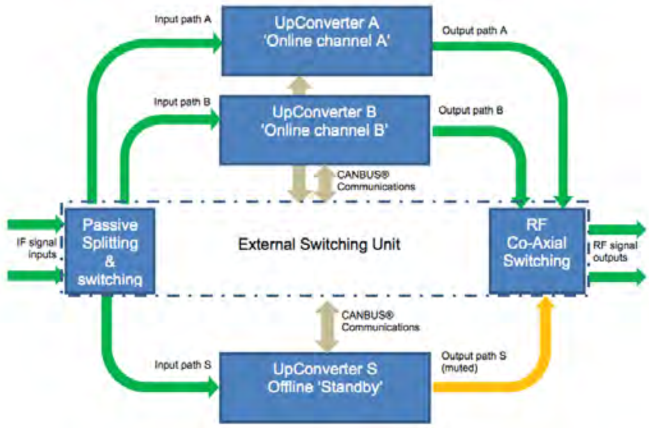


**Fig.4: 2-for-1 Redundancy Upconverter System with External Switching Unit**

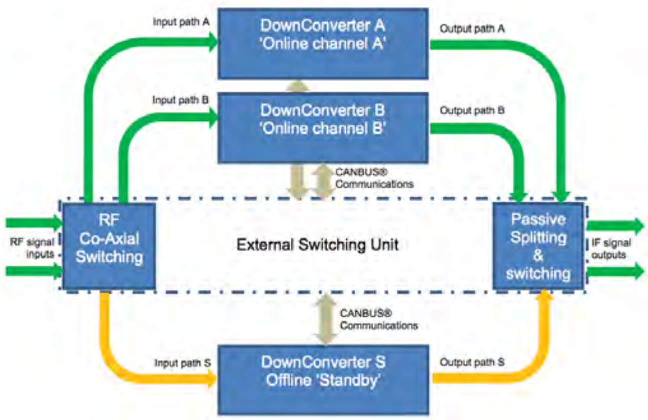


**Fig.5: 2-for-1 Redundancy Downconverter System with External Switching Unit**

## 2-for-1 Redundancy with an External Switching Unit

Similar to the previous 1-for-1 configuration, an external switching unit is used that is now controlled by two on-line units, switching the off-line unit into the appropriate path. (see Fig.4 and Fig.5)

All converters monitor the alarm status of the other units and control the coaxial switch positioning. If an online converter develops an alarm condition, the standby converter will assume master control, configure itself to replicate the appropriate online unit and initiate switching, routing itself to the appropriate output. Priority can be set, so that if there is a second failure the higher priority path will remain operational.

Generally for any 2-for-1 system, reliability/ availability of each path is slightly reduced when compared to two 1-for-1 systems, since in the case of a double failure there is no redundant unit available for the second path.

Due to the additional channel switching, the loss is greater than with a 1-for-1 system, and would typically be 8dB (does not include converter gain) through the system.

This configuration is available with priority path setting,

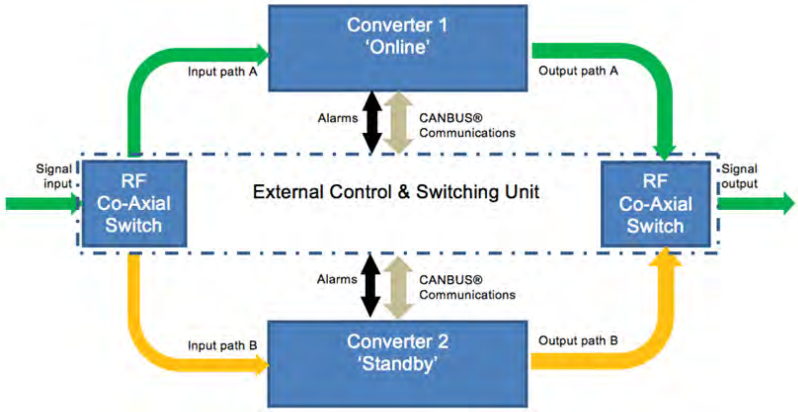


**Fig.6: 1-for-1 Redundancy with a Stand-Alone External Control Unit**

and can be partially populated (with only two converters), to behave like a 1-for-1 system.

## Redundancy with a Stand-Alone External Control & Switching Unit

Traditional implementations utilize external, stand-alone, fully co-axial switched redundancy units. Additionally the switch units can be used for either Up or DownConverters. (see Fig.6)

These external control & switching units typically are

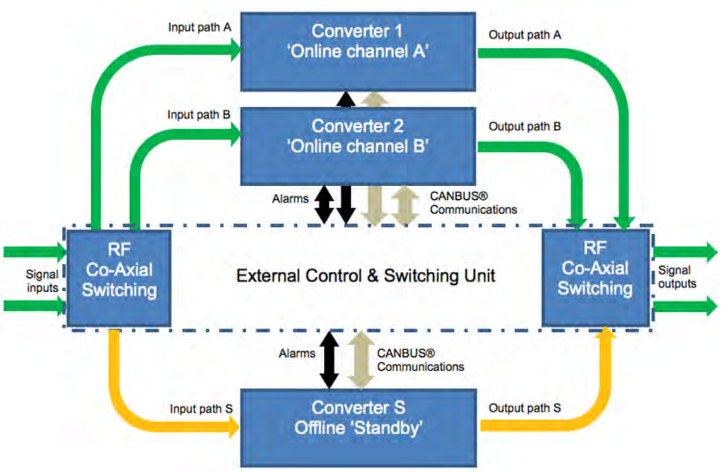


**Fig.7: 2-for-1 Redundancy with a Stand-Alone External Control Unit**

available for manual or automatic mode, depending on the capability to automatically configure the gain and frequency settings of the offline converter unit to replicate the online converter at the time of change-over. This is performed via the CANBUS® interface.

Changeovers are minimized, i.e. a unit taken off line due to an alarm, will remain off-line even if it returns to the non-alarm state. If it does return to the non-alarm state then it will act as the standby unit.

As co-axial switches are used for both input and output switching, the biggest advantage of these configurations is the minimized loss, which can be typically 3dB (does not include converter gain) through the system.

In a 2-for-1 system the priority can be set so that in the event of both online converters becoming faulty, the standby unit is switched to the highest priority path. (see Fig.7)

For a 2-for-1 redundant system the expected path loss (not including converter gain) is typically 5dB through the system.

## n-for-1 Redundancy with a Stand-Alone External Control & Switching Unit

Similar to the 2-for-1 configuration above, systems can be implemented for a range of n-for-1 switching units. The separate control and switching units are typically modular in a larger-than-1RU chassis and can be either partially populated to suit the exact number of ways required, or fully populated to allow for future expansion by simply adding converters, as required.

## Summary

Now back to the football game – every consumer would prefer not to have to deal with equipment failure. After all, it's not their fault and they paid for the service. So she/he should be able to see every pass and its analysis, and even the commercials, without interruption. However satellite earth station operators have to weigh the pros and cons of their redundancy implementations, cost versus availability and reliability. The P7000 Series converters from Peak Communications support all the previously described redundancy scenarios with their low-power satellite earth-station equipment.

**Dr. Andrea Franz,** Partner at A.G. Franz Associates, LLC, has over 25 years of engineering and program management experience in the telecommunications, aerospace, and broadband media industries. Dr. Franz received her PhD in Electrical Engineering from the Technical University of Vienna, Austria. She is a member of the Institute of Electrical and Electronics Engineers (IEEE) and the Society of Women Engineers (SWE). Dr. Franz is the author of several technical papers. She can be reached at: andrea@agfranz.com