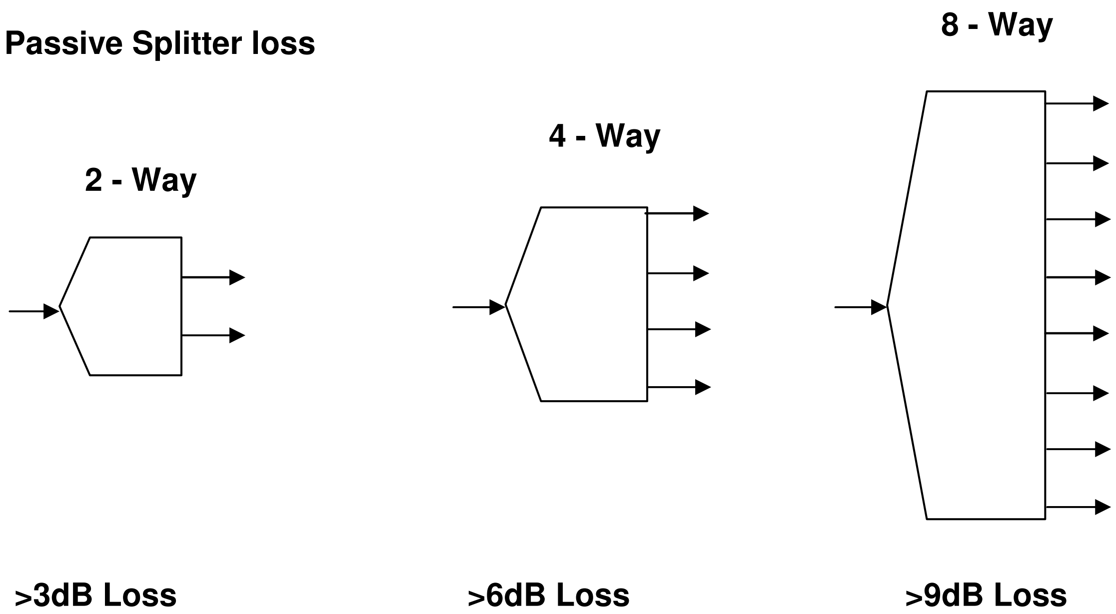
Multicouplers General

A multicoupler is a device which connects a signal source to multiple units. The most common arrangement is for splitting a single antenna so that it can feed a number of receivers. The aim, is to do this in a 'lossless and transparent' manner. Generally people are aware of what are commonly described antenna splitter units, passive devices which split the coax in 2 or more ways. These have loss and effectively add noise which increases with the number of splits required. Due to design topology, splits are normally binary 2, 4, 8 etc, and with a dB loss which is equivalent to the number of splits, i.e 2 – way splits have 3dB loss, 4 – way splits have 6dB and 8 - way splits have 9dB. These figures are theoretical, due to circuit losses the actual losses are 0.5-1dB above the theoretical figure.



As can be observed, when using a passive splitter, losses to an incoming signal can be quite high. To overcome this generally an amplifier is placed ahead of the splitter. Dependent on the range of frequencies to be split different approaches are taken. The splitting elements themselves tend to have characteristics which limit the band to a range of frequencies that are efficiently split.

Types of Splitter:-

1/ Printed Hybrid – UHF and above tends to narrow bandwidths < 20%. Wider bandwidths are possible but size increases and o/p to o/p isolation is reduced….

2/ Transformer 'hybrid'. The use of baluns and impedance matching transformers, often ferrite loaded cores can cover many octaves but are generally used below 1 GHz.

3/ Resistive Splitter – The use of resistors to both split and impedance match are really not suited to the use in splitters for receivers as they offer high loss and very little Isolation port to port. In measurement instrumentation however they are used for their exceedingly wide frequency range and O/P to O/P tracking and matching.

Returning back to application in regards to various bands. Generally for high performance LF/HF and low V/UHF the best choice is a ferrite loaded transformer.

Amplification (Noise Figure)

As previously established, an amplifier is often used ahead of the splitter to reduce loss. This amplifier needs to cover the whole band with a flat response. Another important parameter for the amplifier is its noise figure. Essentially any loss ahead of a receiver directly adds to the system noise figure. For example, a receiver with a 5dB noise figure which is preceded by a 4 way splitter with say 7dB loss will have a system noise figure of 12dB. The amplifiers noise figure is important as when combined with the splitter the composite resultant Noise figure needs to be as low as possible. This is often referred to a 'second stage contribution', and is highlighted in the cascaded NF Friis formula:-

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \cdots + \frac{F_n - 1}{G_1 G_2 G_3 \cdots G_{n-1}},$$

where F_n is the noise factor for the n

At Low frequencies < 1Mhz this may not be a problem due to atmospheric noise prevalent at these frequencies. As we go higher in frequency the background atmospheric noise drop's off, by the time we reach 30Mhz the system would be impacted, we really need System NF to be less than 4-5dB. As we move higher in frequency system NF is all important and figures of 1-2dB (or less are required for any high performance receiving system.

Amplifiers for the HF band.

HF, which generally is considered to cover 1-30 MHz is an interesting band. Often it is crowded with multiple users, from Military to Commercial and Radio Amateurs. Some users have very high power whilst others are relatively low. The bands themselves tend to vary in propagation throughout the day, the season and rotate on an 11 year sunspot cycle. The signals themselves can be from fractions of a microvolt to tens of millivolt's. Because of this, reception systems at HF require amplifiers which are wideband, have reasonably low NF (<5dB) and have good linearity resulting in 'high dynamic range'.

Dynamic range.

When using a broad band amplifier. Its overall linearity, the ability to amplify and not distort is paramount. In a high linearity amplifier this means that multiple signals are amplified at the same time with little distortion. Any non linearity present would result in 'mixing' of the multiple signals. This is referred to as Intermodulation. The presence of intermodulation in a wideband system means that when trying to receive low level signals, intermodulation products from large signals may fall on wanted low level signals, making them unreadable. When talking about dynamic range were referring to the lowest signal that may be seen through the amplifier (relates to NF) and its ability to amplify without causing any intermodulation products. The figure of merit given to linearity is the amplifiers 'Third order intercept', an imaginary point on a graph where fundamental tones and the third order products would cross.

A high dynamic range amplifier therefore requires good low noise and have high linearity. In amplifier design, due to the geometries involved with the raw devices (Transistors , FETS etc) Low noise figure and High TOIP are in opposition.

Types of Amplifier.

1 – Small signal – Here we consider amplifiers which may have low output power/linearity but good low noise performance.

2 – Medium power amplifiers – These are amplifiers that can exhibit high linearity while the noise figure may be somewhat higher than the small signal.

In the search for a high linearity amplifier yet low noise, HF amplifiers for multicouplers, have historically been push pull medium power types. Generally the market has considered that an amplifier with a TOIP of +35-39dBm and NF of 5dB to be acceptable at HF.

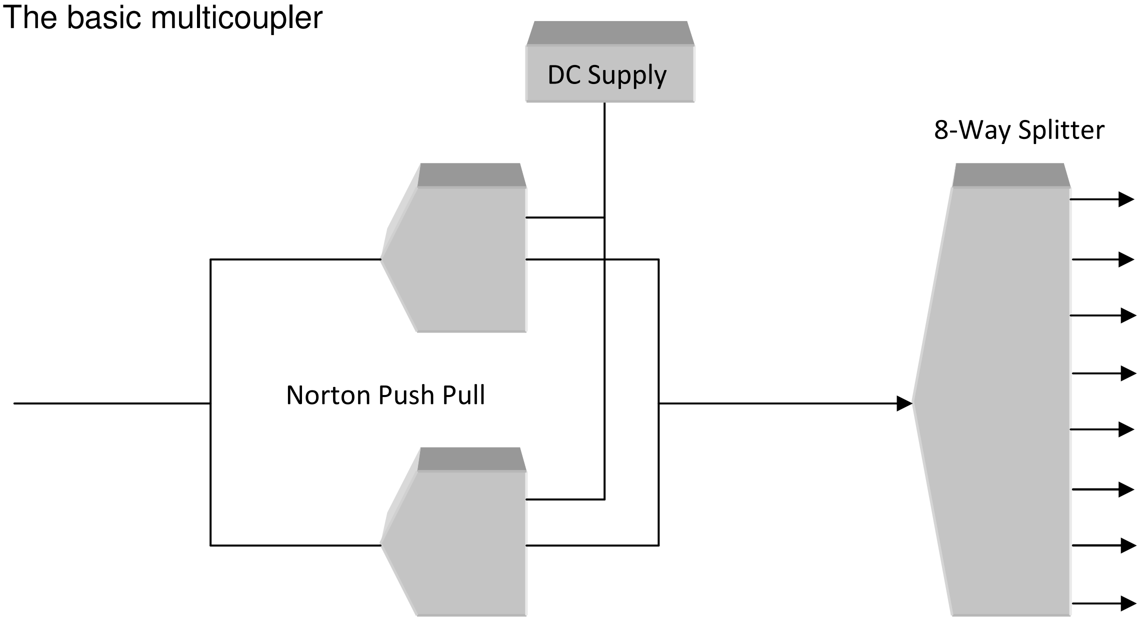
Amplifiers for Multicouplers (the 'Norton' Solution..)

HF Multicouplers tend to be 8-way or more. As can be seen an 8 Way has approx 10dB loss. To overcome this loss the preceding amplifier has to have a gain of 10dB or slightly more. It is also important to note that the TOIP of the amplifier is reduced dB for dB by any loss after it. Therefore to have an +35dBm TOIP multicoupler (8 Way) we need the amplifier to have a TOIP of > +45dBm, whilst maintaining a low noise.
In an effort to reduce power consumption, which is high on any medium power (Class A) amplifier Stancom has been using an effective but novel design. This was first introduced by David Norton in his paper:-

Norton, David E., "High Dynamic Range Transistor Amplifiers Using Lossless Feedback," Proceedings of the 1975 IEEE International Symposium on Circuits and Systems, pp. 438-440.

By using a bipolar device in his "lossless feedback" configuration, extraordinary performance may be produced by a small signal device. Using the latest components currently available, a small signal push pull design developed at Stancom has resulted in a low current solution with ‘high current class A performance’.

The basic multicoupler



The above diagram shows a multicoupler block diagram. Target specification for such a device follows:-

Frequency	1-30MHz
Gain	+1dB +/- 0.5dB
TOIP	>+35dBm
NF	<6dB

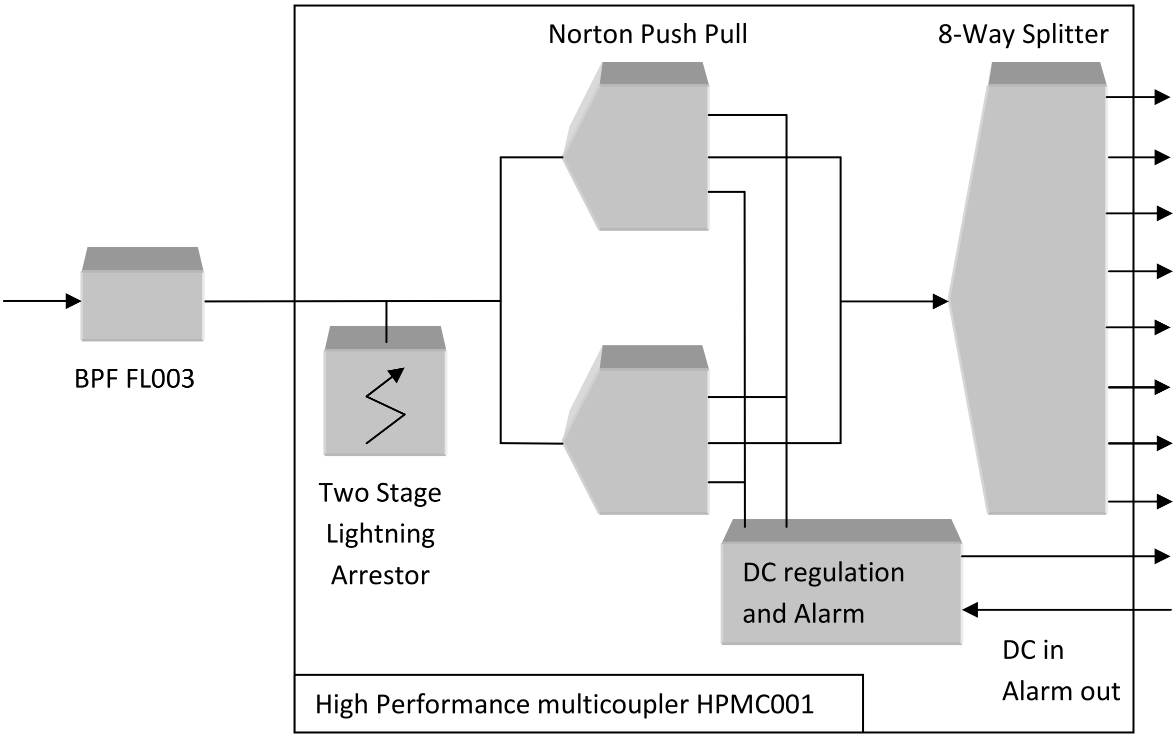
Stancom produces the above as the High Performance Multicoupler ‘ 001’ or HPMC001. It is a low cost solution with excellent specifications…

Additional considerations

Output to Output Isolation. – This ensures that any spurious from a connected receiver to any other receiver is reduced. Typically a figure of >30dB is achieved.
Input protection from lightning – Overdrive and lightning protection needs also to be considered. Stancom fits a 2 stage design providing protection from near lighting
Alarms. – The amplifier itself is an active device and therefore subject to failure. These two amplifiers are monitored independently and a local alarm LED indicates ‘Status’. A remote alarm is also possible via an OPTO coupler to remotely give a failure alarm.
Filtering – The core amplifier is considered adequate for handling the signal strength of signals within the HF band. However, station proximity to local MW transmissions may cause problems. Because of this Stancom can provide an

external filter such as the FL003 band pass which attenuates both MW and VHF unwanted signals.

The complete multicoupler System



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