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Product Description

L-Band Block Upconverter (BUC)

Introduction

The basic architecture of a conventional satcom terminal is derived from the historical desire to keep the design and supply of the hardware items as free and open as possible. Over the years, this concept has promoted global competition at every functional hardware block, and has dramatically improved designs and reduced costs to the end user. However, as operating requirements change and technology advances, system architecture must be modified to take advantage of the additional cost and performance benefits that can be realized. A CPI amplifier with an integrated L-band block upconverter (BUC) offers the opportunity for significant cost and reliability savings in low and medium data rate applications by eliminating costly duplicated functions in the conventional RF terminal chain.

CPI (formerly Varian Electron Device Group) has been active in the design and manufacture of microwave power amplifiers and related products for more than 35 years. The Satcom Products Group of Satcom & Medical Products Division (SMP) manufactures both GaN and GaAs based solid state amplifiers (SSPAs and BUCs); traveling wave tube amplifiers; klystron power amplifiers; and solid state transceivers.

Over its history, CPI has provided thousands of fully integrated satellite uplink power amplifiers in the S, C, X, Ku, DBS, Ka and Q-band frequency ranges to users worldwide and has become the leading supplier of this class of products.

Description

L-Band input starts at the lower end point of 900 or 950 MHz, and stretches from 500 to 1100 MHz. Please take care to ensure that the proper L-band frequency range is not exceeded or damage may result. The signal must be free of spurious signals that can cause poor performance or even cause the amplifier to fail. The L-band input signal can be translated to the following microwave bands:

- 5.850 – 6.425 GHz
- 5.85 – 6.65 GHz
- 5.850 – 6.725 GHz
- 7.9 – 8.4 GHz
- 14.0 – 14.5 GHz
- 13.75 – 14.50 GHz
- 12.75 – 13.25 GHz
- 17.3 – 18.1 GHz
- Ka-band (up to 1 GHz within the 27.5 to 31.0 GHz frequency range)
- Triband (5.85 – 6.65 GHz, 7.9 – 8.4 GHz and 13.75 – 14.50 GHz)

If the BUC Local Oscillator (LO) reference fails or drifts outside of the capture range, a "BUC alarm" signal will be reported on the optional CPI remote panel or through the supplied "Setup & Remote software." The alarm will be reported via the CIF port, but the amplifier will take no action. Alternatively, the BUC alarm can be set to a latched fault via a user setting in the CIF protocol (using the supplied utility software or the 1 RU remote control panel). In the event that the BUC LO becomes unlocked, a fault will be reported, and the amplifier will inhibit RF and shut down HV to the TWT. A reset command will restore the amplifier to normal operation once the fault has been cleared.

Figure 1 (below) shows the conventional satcom terminal with customer analog and digital information passing through a physically stand-alone modem, upconverter, downconverter, HPA and LNA. All of the equipment except for the LNA is installed indoors, with the high power microwave transmit signal delivered to the antenna via low loss waveguide, and the amplified microwave receive signal from the LNA delivered to the downconverter via low loss coax cable. In this system, there are three high stability crystal reference oscillators and four synthesized frequency generators, contained in five physically separate pieces of equipment.

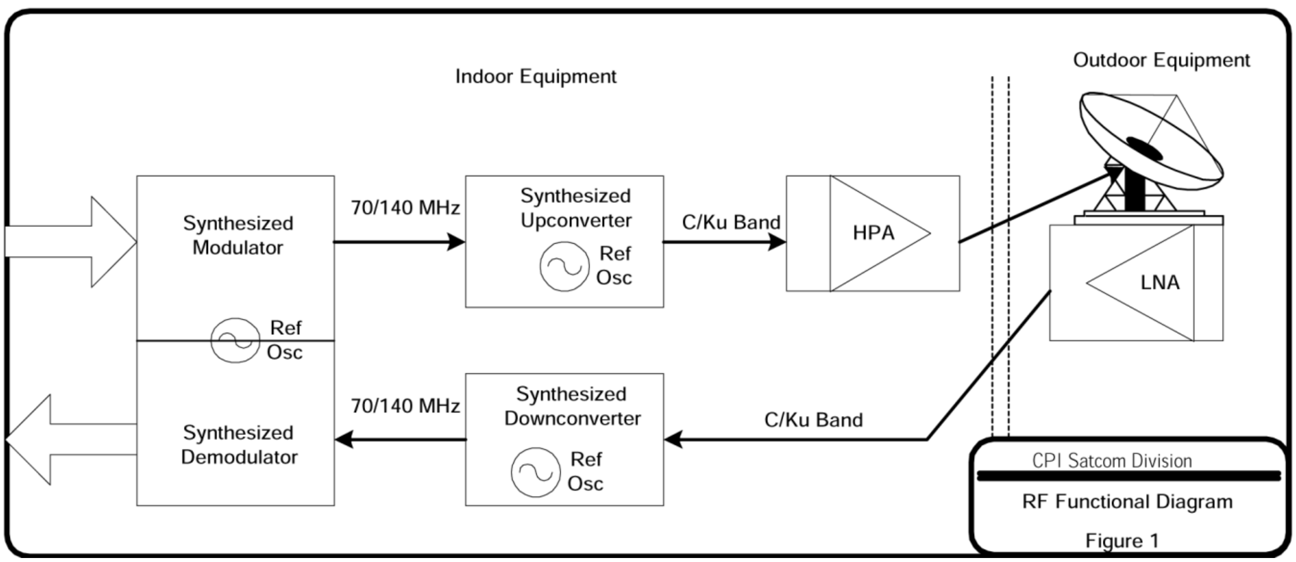


Figure 1

Figure 2 (page 3) shows a modification of this design, where the HPA has been moved outdoors and installed directly on or adjacent to the antenna. This increasingly common concept reduces the losses in the high power microwave signal between the HPA and the antenna, which can be prohibitive in some cases. In any event, it does nothing to eliminate the number of physically separate equipment boxes or the duplicated functions in the chain.

CPI offers a complete line of HPA products and systems for customers who are designing systems around these two architectures.

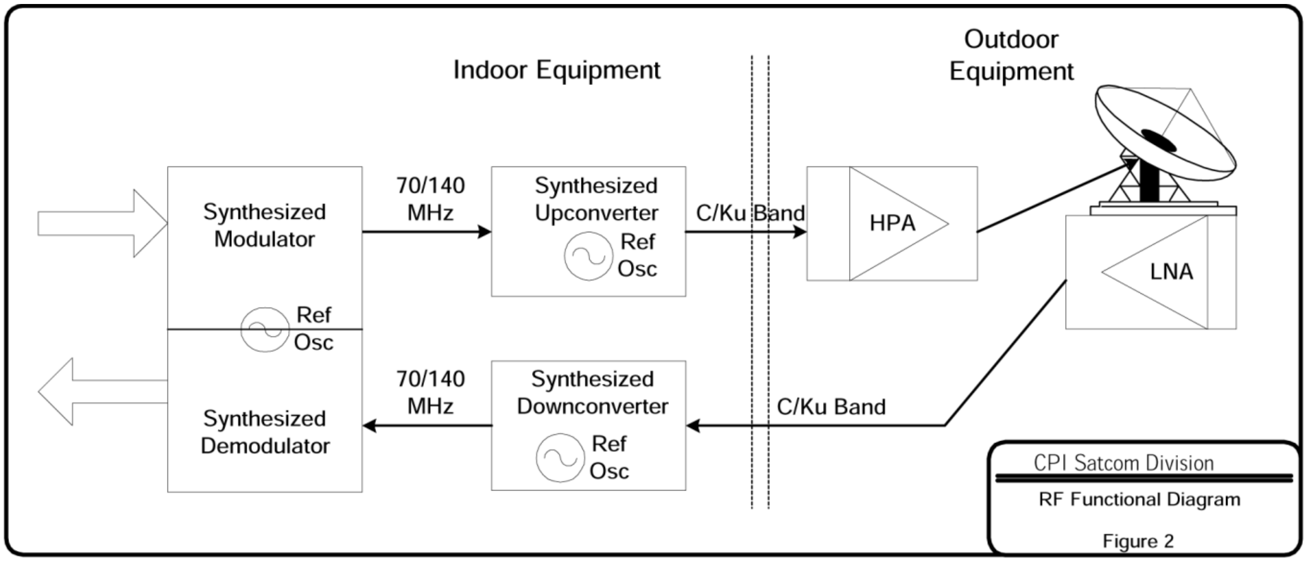
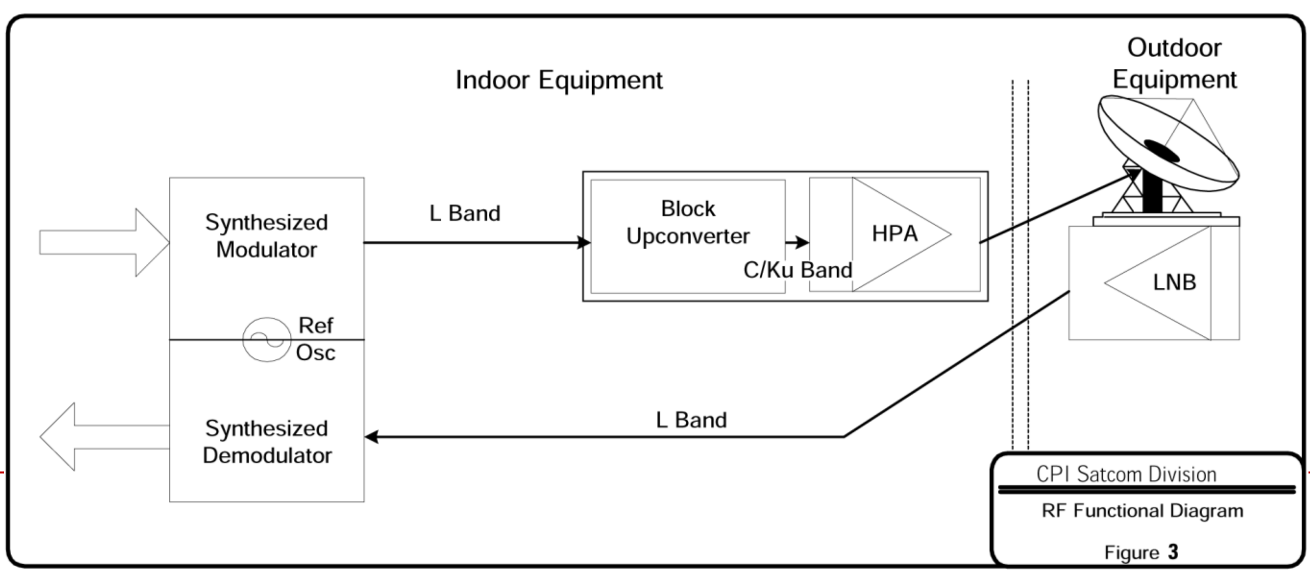


Figure 3 below shows how a CPI amplifier with the new High Power Block Upconverter which eliminates unnecessary oscillators and synthesizers. It reduces the number of physical boxes to three, including the LNB. Advances in phase shift modulator technology have led to a number of companies offering PSK modems that translate directly from customer baseband information to the L-Band region. By eliminating the added conversion step between the customer data and the microwave satcom frequencies, costs are reduced and a full set of undesired spurious frequencies are avoided. Since the modem already contains a highly stable reference oscillator and fine-tuning step synthesizer, there is no need to duplicate these functions in the microwave converters. This allows the use of a simple wideband block converter that can cover the entire C or Ku band satellite bandwidth in one step without tuning. By integrating this block converter inside the HPA, one physical package is eliminated, as is one set of equipment power supply, RF and M&C user interfaces. The block converter can be imbedded into standard CPI HPAs with minimal impact on size. DC power and reference signals for the upconverter can be supplied by the modulator. Using an LNB instead of an LNA plus downconverter represents a further significant cost saving. While Figure 3 shows the block converter



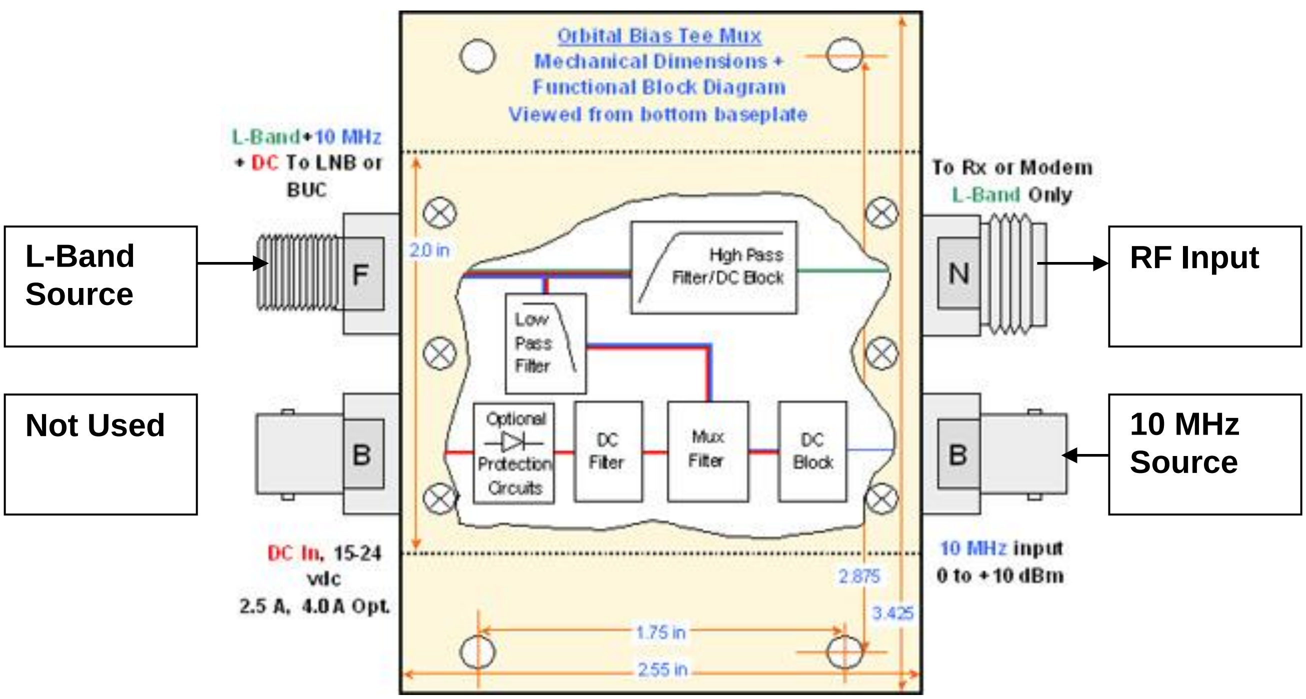
integrated into an indoor rack mount HPA, it can also be integrated into CPI's hub mount HPA products.

Configurations

Several options are available for the Block Upconverter (BUC):

MUX Reference: Most L-band modems now have a built-in 10 MHz reference. The CPI BUC can be configured to accept this reference, which is multiplexed with the L-band signal on the same connector. This is CPI's standard configuration, and is recommended for most applications. The MUXed 10 MHz reference must be in the range of -5 to +5 dBm to stay in lock. Care must be taken not to attenuate this signal below -5 dBm when controlling the L-band input. To control the power level use the internal HPA attenuator, which will not affect the 10 MHz reference. A system-level power lineup will be helpful to ensure proper operation though all levels.

CPI uses an Orbital Research MuxTee to set up and test the signals, which can be found at http://www.orbitalresearch.net/MT-25_MuxTee.htm. The setup is as follows:



Internal Reference: CPI can supply a BUC module that includes an internal 10 MHz reference signal with ±1 ppm stability. This oscillator performance level is not as precise as a GPS reference, but is adequate for many applications.

External Reference: Allows user to connect a system 10 MHz reference through a BNC cable. This is used for systems that need to slave all HPAs to a common timing reference, such as the GPS signal. The level required is –5 to +5 dBm.

Lock/Alarm/Fault: The CPI BUC module has an internal detection circuit to signal when phase lock to the 10 MHz reference, whether internal or external, is lost. As standard, CPI HPAs report this event as a fault to initialize switchover to a backup HPA. As an option, the user can specify that lock-loss be an alarm to the System M&C. This avoids any downtime in the case of a non-redundant uplink. The Fault/Alarm configuration can be changed through the front panel, or in the case of outdoor designs, through the serial port.

Notes

- Spurious Signals – spurs separated from carrier by multiples of 10 MHz may occur if the combiner's ports are not well isolated
- Noise Floor – The noise floor is 6 dB higher with the BUC than without.
- Saturation – To ensure that BUC is not saturated, input to the BUC should not exceed the necessary input power level by more than 3 dB, to reach P(rated) of the HPA with a minimum attenuation setting (**please refer to test data of HPA for recommended operation levels**).
- CPI strongly recommends the use of a BIAS T to sum the 10 MHz signal with the L-Band.
- All CPI amplifiers with a BUC meet MIL-STD-188-164A and Intelsat IESS-308/309 phase noise standards.
- The input VSWR of the HPA will increase to 1.5:1 with internal BUC.

ADDENDUM 1

Do you need a BUC with an internal 10 MHz reference, or should you use an external reference signal source?

The answer to this question is related to the frequency shift tolerance of the receiver being used in your system. On the transmit side, each CPI supplied BUC with the internal 10 MHz reference has a frequency tolerance of +/- 2 parts per million (ppm) over –40 to + 85 degrees C.

To calculate the frequency shift range, the following formula applies:

(ppm shift specification * (10^{-6})) * (Frequency in GHz * 10^{9}) =
(Frequency shift amount) * 10^{3}

So, if we take an example of using a CPI supplied BUC with internal 10 MHz reference (with a frequency shift specification of 2 ppm) and an RF transmit frequency of 14 GHz, the formula looks like this:
$(2 * 10^{-6}) * (14 * 10^{9}) = (28) * 10^{3}$ or 28 kHz

Given the above calculation, 28 kHz would be the potential frequency shift over the specified temperature range for a single unit. Using the same figures, if you are operating a 1:1 system, this means that the potential exists for the delta between unit one and unit two to be 4 ppm (i.e. minus 2 ppm in unit one, and plus 2 ppm in unit two). This means that the potential shift is two times the result, or 56 kHz, as shown below:

$(4 * 10^{-6}) * (14 * 10^{9}) = (56) * 10^{3}$ or 56 kHz

In the 1:1 redundant system case, if you are transmitting at 14 GHz, using a 1:1 system, and your receiver system can tolerate a a 56 kHz frequency shift over the specified time period, then having a BUC with an internal 10 MHz reference will be sufficient. The same applies if you are using a single unit at 14 GHz, and your system tolerance is 28 kHz).

However, if you require a more stable upconverter, then it is recommended that you use a BUC that requires an externally supplied 10 MHz reference signal. This signal is provided to the HPA(s) simultaneously, so that the HPA(s) has (have) a single 10 MHz reference signal to work with. This will eliminate the frequency difference between multiple units.

ADDENDUM 2

Regarding Bandwidths Greater than 1 GHz

For applications greater than 1 GHz, CPI recommends the use of dual/multiband (switchable) block upconverters (BUCs). These BUCs have at least two bands, and allow the user to switch the band of operation via the M&C interface. Note that the use of switchable BUCs means that the entire wide band cannot be used all at once.

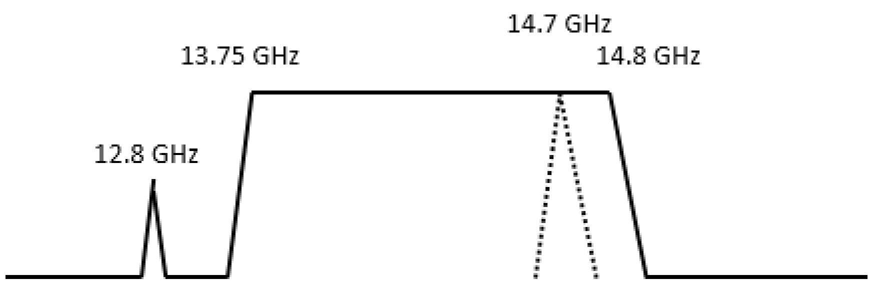
CPI is aware of technology that enables BUCs to operate at bandwidths wider than 1 GHz, using a single, non-switchable Local Oscillator (LO). However, our extensive experience with this upconversion technology has revealed two very formidable technical challenges:

1) A lack of availability of wide band, single band modems which actually support such up conversions
2) An in-band spur that results from the ‘2* Input Frequency + LO’ (2IF+LO) result.

Availability of modems
While there are modems that are available for greater than 1 GHz operation, our experience is that the cost can be prohibitive.

In-band spur at 2LO+IF

When using a single LO BUC that is wider than 1 GHz along with the standard, commercially available LO, an in-band spur will appear due to the 2*IF+LO phenomenon. The below graphic demonstrates this in typical Ku band frequencies.



In such a case, the parameters are:

- Output band: 13.75-14. 8 GHz
- Input Frequency (IF) in L-band : .950-2.000 GHz
- LO[1] : 12.8 GHz

When operating in this wide band with this single LO BUC, the user would see a spur at 14.7 GHz, which is in-band. The location of this spur is calculated as 2IF + LO or (2 x .950) + 12.8 = 14.7.

In such a scenario, CPI would recommend a dual or multi band switchable BUC (which would include a dual or multiple LOs, respectively). Please contact CPI for more details on the availability of dual or multi band BUCs.

[1] LO is calculated by taking the low end of the output frequency band and subtracting the corresponding point of the input frequency band.
In the Ku band example above, that is: 13.75 minus 0.95 = 12.8 GHz

ADDENDUM 3

Can you use an internal BUC in power-combiner mode?

We do not recommend it. Internal BUCs with external reference options may work, however the following drawbacks apply:

1. If the external reference fails and the BUCs are automatically switched to internal crystals, phase combined operation will be lost. It is not possible to phase match two internal reference sources for an extended period of time, even if the user manually

sets the phase of each oscillator for a ‘zero beat’ initially. This is because the BUCs will have different frequency drifts with temperature.

2. Depending on the BUC supplier, where sometimes the phase-locking scheme is less than perfect, occasional frequency-wander might occur. In other words, the BUCs could momentarily lose lock without any ‘phase lock alarm’ indication, and then regain lock. This “lose-regain lock” cycle would then occur repeatedly. This also causes PC operation to be lost.

3. Phase match between two BUCs driven by the same reference cannot be guaranteed.

CPI can provide this type of system at the insistence of the buyer, but the buyer must acknowledge and take responsibility for the potential risks of the system.

ADDENDUM 4

Alarm/Fault configurations for TWTAs with BUCs

CPI uses the same alarm/fault configuration for the vast majority of its traveling wave tube amplifiers, which are listed as follows:

C-Band: T5CI, T07CO

X-Band: T5XI, TL05XO, T07XO

Ku-Band: T5UI, T5UI-12, TL02UO, T02UO-2G, TL04UO, T07UO, T07UO, TL07UO, TL12UO, T9UI

DBS-Band: T5DI, T07DO, T07DO, TL12DO
Ka-Band: TL01KO, TL02KO, T05KO, TL05KO, TL05KO, TL06KO, C07KO

For the TWTA models listed above, and only those model numbers, the alarm/fault configuration is as listed below:

INTERNAL 10 MHz REFERENCE ONLY: factory software selected to FAULT when internal reference lock is lost;

MUX REF ONLY: factory software selected to FAULT when external (or MUX) reference is lost;

EXTERNAL REF ONLY: factory software selected to FAULT when external (or MUX) reference is lost;

EXTERNAL REF with STAND-BY INTERNAL REF: factory software selected to ALARM when external (or MUX) reference lock is lost, and FAULT when internal reference lock is lost;

MUX REF with STAND-BY INTERNAL REF: factory software selected to ALARM when external (or MUX) reference lock is lost, and FAULT when internal reference lock is lost.

For all other TWT amplifiers, please contact CPI.