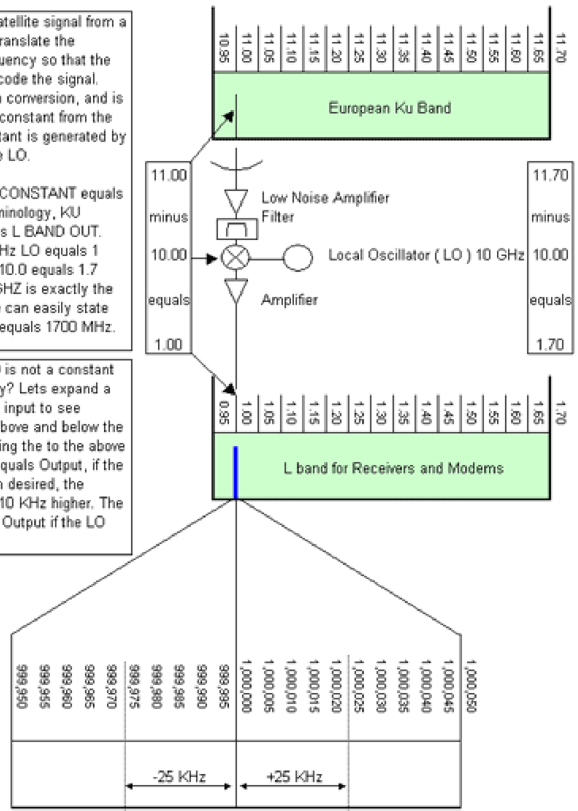
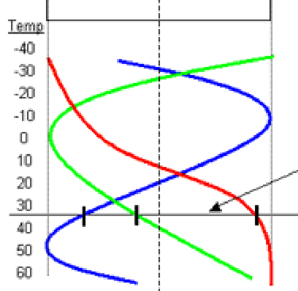
To receive and process a satellite signal from a Ku bird, it is necessary to translate the satellite signal down in frequency so that the modem can receive and decode the signal. This process is called down conversion, and is simply the subtraction of a constant from the input frequency. This constant is generated by a Local Oscillator called the LO.

Very simply, INPUT minus CONSTANT equals OUTPUT, or in satellite terminology, KU SIGNAL IN minus LO equals L BAND OUT. Thus 11 GHz in minus 10GHz LO equals 1 GHz OUT, and 11.7 minus 10.0 equals 1.7 GHz. Keep in mind that 1 GHZ is exactly the same as 1,000 MHz, so we can easily state 11.7GHz minus 10.0 GHz equals 1700 MHz.

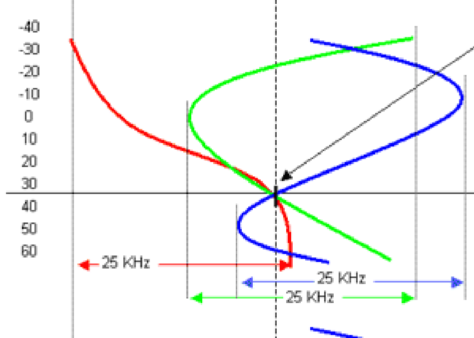
But what happens if the LO is not a constant frequency, and drifts slightly? Lets expand a single frequency of 11 GHz input to see 0.000050 GHz or 50 KHz above and below the desired frequency. According the to the above equation, Input minus LO equals Output, if the LO was 10 KHz higher than desired, the Output must follow and be 10 KHz higher. The curves below represent the Output if the LO drifts by +/- 25 KHz



Local Oscillator Drift of plus/minus 25 KHz over temperature causes the IF output to drift the same amount



The red, green and blue curves are three different oscillators, each having a unique and normal temperature characteristic. Note that while all three oscillators only drift +/- 25 KHz, at the nomal operating temperature of +30C, they are NOT at the desired LO frequency, they are "Offset".

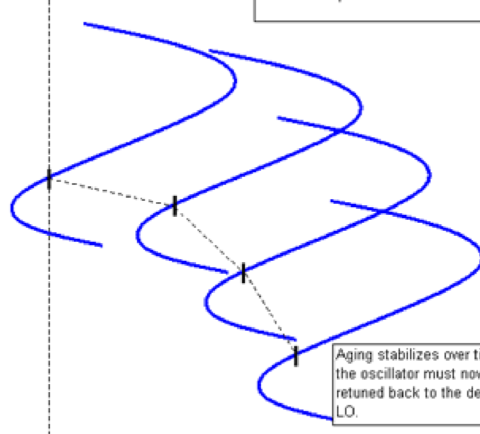


If we set each oscillator to be on the LO frequency at room temperature, the drift characteristics of each are still +/- 25 KHz but are not centered around the LO. The red curve now drifts +5, -45 KHz, the Blue curve drifts +40, -10 KHz, and the Green curve +30,-20 KHz relative to the desired LO. Please note that the drift has not increased, it is still + or - 25 KHz, but the offset has been zeroed at the normal operating temperature.

This is a completely NORMAL operating condition, but often it is not what the customer expects

There is another characteristic of quartz crystals that must be considered. Quartz changes frequency with age. Fortunately, aging is not a linear relationship with time, and is most pronounced within the first year of use. Simply put, the frequency of the crystal at normal operating temperature changes. The drift characteristics usually do not change much, but the 'Offset' can become significant. If a crystal is 'rushed' into use and not artificially aged by exposure to a constant high temperature for four weeks, the aging curve is steep.

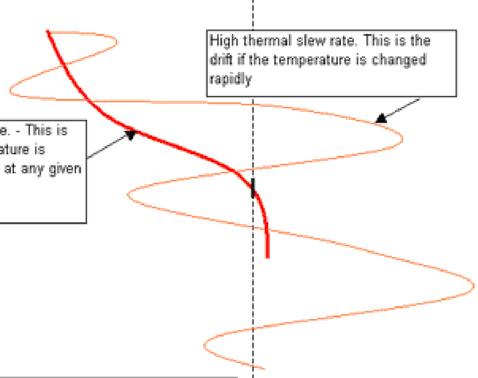
Also keep in mind that the quartz crystal oscillates in the 15 MHz region, but is controlling a local oscillator in the LNB that is at 10 GHz, so 1 Hz of change in the quartz crystal of 15.625 MHz means 640 Hz at the LO. Therefore, a 10 KHz drift in the LO is a change of 0.0001 percent.



Aging stabilizes over time, but the oscillator must now be retuned back to the desired LO.

High thermal slew rate. This is the drift if the temperature is changed rapidly

Low thermal Slew rate. - This is the drift if the temperature is stable for 15 minutes at any given temperature



There is one last dirty little secret; how is drift measured and specified? The industry standard is to put an LNB into a temperature chamber, feed a highly stable signal in, and measure the L band out on both a spectrum analyzer and a frequency counter. The trick is that the measurement is taken ONLY AFTER the LNB has been at a constant temperature for a minimum of 15 minutes.

This is actually quite logical since it takes quite a few minutes for any temeprature change to get to the crystal. After all, the little chip of quartz is sealed inside a metal housing, surrounded by insulating air, and that housing is mounted on an oscillator, which has three separate temprature compentsation networks, which is mounted inside a metal enclosure with insulating air, and this enclosure is mounted on a circuit board that is in a metal housing insulated with air. The bottom line is that it takes a fair amount of time for the crystal to reach the same temperature as the air around the LNB.

Before the crystal changes temperature, the compensation networks are changing temperature and are adjusting the oscillator as if the crystal has already changed. This can lead to dramatic swings in frequency as all components slowly reach the same temperature and are actually compentsating for the correct crystal temperature. It is not unusual to have 50 to 100 KHz swings in oscillator output as the components stabilize at a given temperature.

Here is the horrible part. The weather does not change temperature slowly and constantly. A sun shower, or any dramatic change in temperature can induce a thermal swing that will exceed the specified drift parameter. If drift is an important metric in the clients application, the only solution is to move the crystal indoors into a thermally stable environment. This is called an external reference LNB.