Course Introduction

Purpose
- The intent of this course is to provide you with information about Generation 2 MC44C801 and Generation 3 MC44S802 Silicon Tuner products from Freescale Semiconductor.

Objectives
- Define tuners and explain how they are used.
- Differentiate between silicon tuners and CAN tuners.
- List the advantages of silicon tuners over CAN tuners.
- List applications for silicon tuners.
- Calculate the output frequencies for single conversion and dual conversion tuners.
- Describe the Generation 2 MC44C801 Silicon Tuner IC.
- Describe the Generation 3 MC44S802 Silicon Tuner IC.

Content
- 31 pages
- 5 questions

Learning Time
- 50 minutes

The Freescale Silicon Tuner Technical Training course covers both Generation 2 (Gen2) part number MC44C801 and Generation 3 (Gen3) part number MC44S802 silicon tuner ICs from Freescale Semiconductor. This course begins with an explanation of how tuners work and descriptions of CAN and silicon tuners. It then examines the advantages of silicon tuners over CAN tuners. Next, the MC44C801 and the MC44S802 are described. Finally, this course looks at some of the advantages of using Freescale Silicon Tuners.

What are Silicon Tuners?

Definition:

- **Tuners receive audio/video programming via a radio frequency (RF) broadcast.**
- **Tuners select a single channel from the available channels on the broadcast.**
- **Tuners convert RF signals into a lower, more workable frequency.**
  – RF to intermediate frequency (IF)
- **Silicon tuners are highly integrated circuits that provide this functionality in a single chip.**

Competitive advantages:

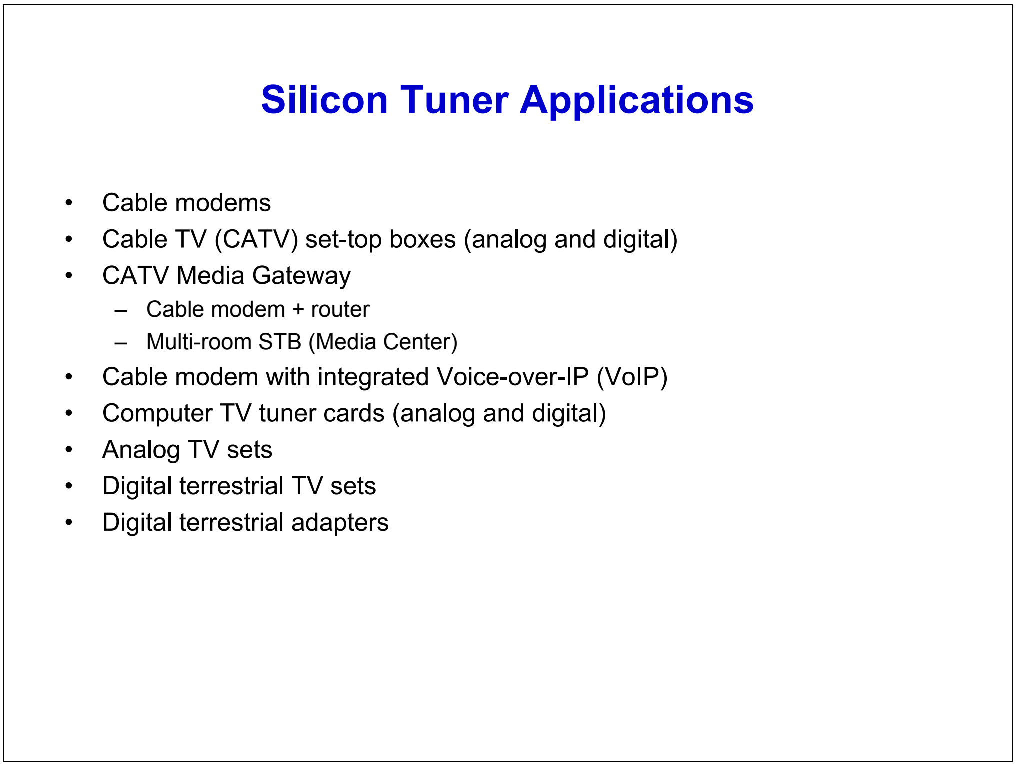
- **Have a lower overall system cost**
- **Have a smaller "footprint"**
- **Run through a standard factory flow**
- **Do not require manual tuning of coils**
- **Have a minimal power estimation calibration time**
- **Perform consistently and do not degrade over time**

Tuners receive audio/video programming via an RF broadcast, then select a single channel from the available channels on the broadcast. The broadcast can be over-the-air (terrestrial), cable, or satellite. Next, tuners convert the RF signals into a lower, more workable frequency. Silicon tuners are highly integrated circuits that provide this functionality in a single chip.

Let's look at some of the advantages of silicon tuners. Ultimately, silicon tuners enable a lower overall system cost. CAN tuners are still competing today; however, they will soon run out of room for further price reductions. In addition, silicon tuners have a much smaller footprint, which allows you to use them in new, more portable applications.

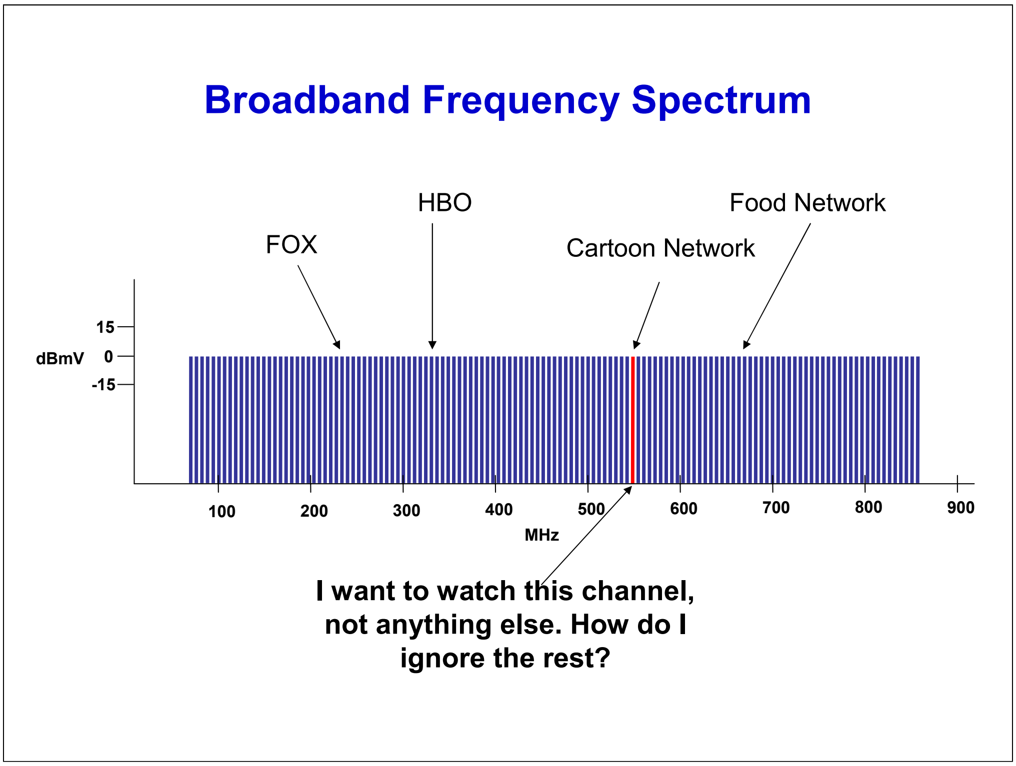
During "end product" production, silicon tuners can run through a standard factory flow, so no hand-soldering is required and they can go though double-sided reflow. Silicon tuners do not require time-consuming manual tuning of coils to provide image rejection. Power estimation calibration time is minimal. For example, one customer reduced calibration time from 2 minutes to 10 seconds using a Gen2 Silicon Tuner. They meet DOCSIS power estimation specifications, and self-diagnostics can further reduce test time.

Finally, silicon tuners reduce costs because they perform consistently; there is little channel-to-channel variation in performance, and they do not degrade over time.



Here you can see some of the market applications for silicon tuners. Gen2, which is the MC44C801, is best suited for digital implementations such as the cable television, cable modems, cable set-top boxes, media gateways, and cable modems with Voice over IP (VoIP) functionality. Additionally, the MC44C801 can be used in computer TV tuner cards because of their relaxed performance specifications.

MC44S802, the Gen3 product, enables Freescale to target a broader set of markets including analog TV, digital terrestrial TV, digital terrestrial adapters, and all analog and digital cable-related markets.



To better understand silicon tuners, let’s look at the background on RF broadcasts and how they're handled.

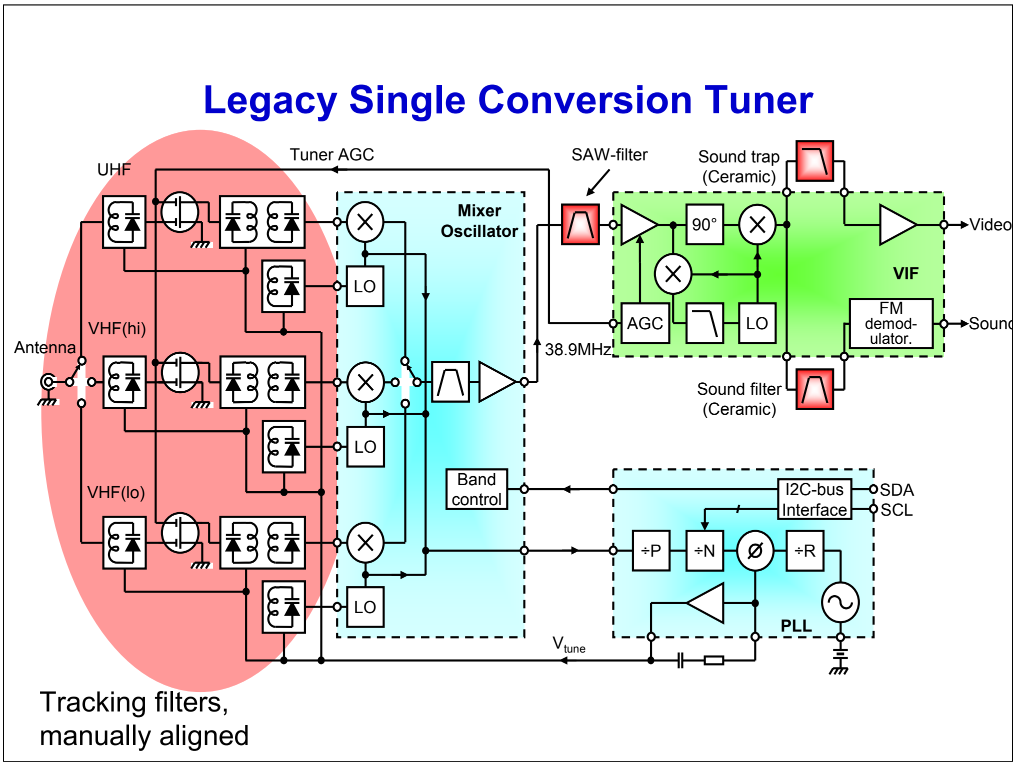
In a broadband cable system, many channels are available to view.

In North America, each channel is 6 MHz wide spread across the 67 MHz to 860 MHz frequency range.

A tuner selects a single channel from the available channels. The tuner must also be agile so that different channels can be selected as the user’s preferences change.

Each channel carries useful information in it such as a series of pictures and a sound track. A process called modulation encodes this information onto the channel when the channel is created at the transmitter. The tuner in the receiver must not damage the modulated signal so that the other parts of the receiver can recover the useful information.

Several methods are used to select an individual channel from the mix, or multiplex as it is called in the cable industry. All of these methods ultimately result in filtering out the energy from the undesired channels, leaving only the energy from the desired channel. The elements used to accomplish filtering include devices that change a channels’ frequency (mixers), amplifiers, and filters.



Here you can see a more traditional tuner. This type of implementation is still used today; however, silicon tuners are gradually replacing them.

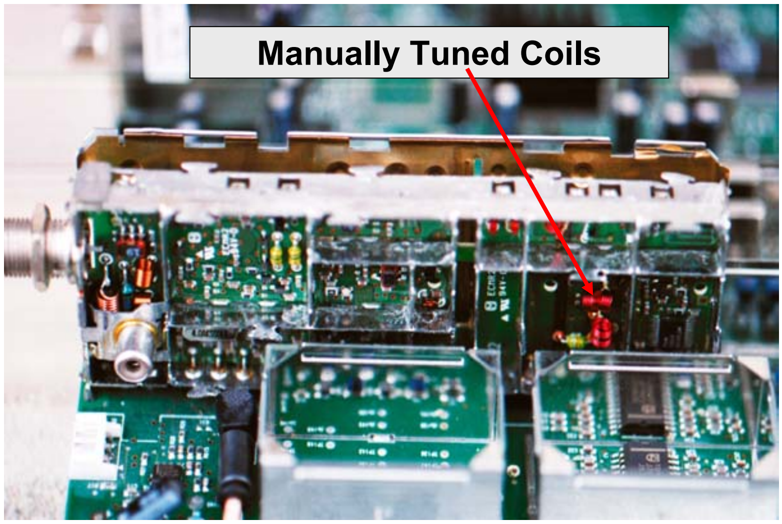
The mixer oscillator array in the center of the diagram selects the channel of interest.

Here you can see the array of filters with the antenna switch. This special type of filter is called a tracking filter. With tracking filters, the pass band can be changed as needed. However, tracking filter designs are limited to a small range of frequencies, so three different filters are needed for TV sets. As the channel is changed, the TV set selects and adjusts the tracking filters.

Tracking filters also require adjustment at the time of manufacture. In the past, a factory employee adjusted the coils to get the desired performance. Even with today's manufacturing equipment, which performs these adjustments with robotic tools, the adjustment of tracking filters adds significant time to the manufacturing process. Finally, tracking filter components have poor temperature and aging characteristics, so a system that works when it rolls out the factory door will suffer degraded performance as it ages and is exposed to temperature extremes.

Today, customers expect devices to work as soon as they come off the manufacturing line and to continue to work for many years. Thus, we need an approach to tuning channels that doesn't use tracking filters.

CAN Tuner



Here we can see an example of a CAN tuner, which is a single conversion tuner. They are called CAN tuners because they were put inside metal cans for shielding purposes.

Note the presence of a hand-tuned coil in the tuner highlighted here. These coils are part of the filtering system. In this tuner, the coil was tuned by inserting a plastic screwdriver between the coil turns and expanding the coil until the performance was within specification. This is a very labor-intensive and time-consuming process. This particular design doesn't have a lot of coils, but the designs used in most TV sets today have many more coils than are visible in here.

Question

What are some of the advantages of using silicon tuners instead of CAN tuners? Select all that apply and then click Done.

Lower overall system cost

Smaller footprint

Tracking filters improve performance

Perform consistently and do not degrade over time

Manually tuned coils allow for custom calibration

Done

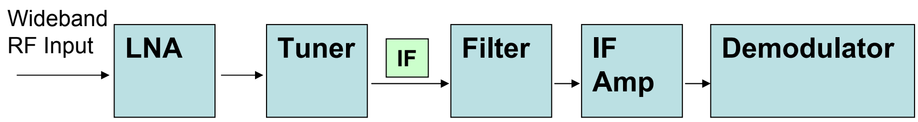
What are some of the advantages of using silicon tuners?

Correct.

Silicon tuners have lower overall system cost, a smaller footprint, perform consistently, and do not degrade over time. Manually tuned coils are a characteristic of CAN tuners, and the process is time-consuming and labor-intensive. Tracking filters, characteristic of legacy tuners, also require manual adjustment and degrade over time.

RF Front End Basics

Mouse over each block to learn more about modern tuners.



Low Noise Amplifier (LNA): The LNA adjusts the variations in power between channels and over time.

Tuner: The tuner selects the frequency of interest, and the output is always at the same frequency. The tuner selects the channel of interest from the input, filters out some of the other channels, and converts the channel of interest to a fixed-frequency output.

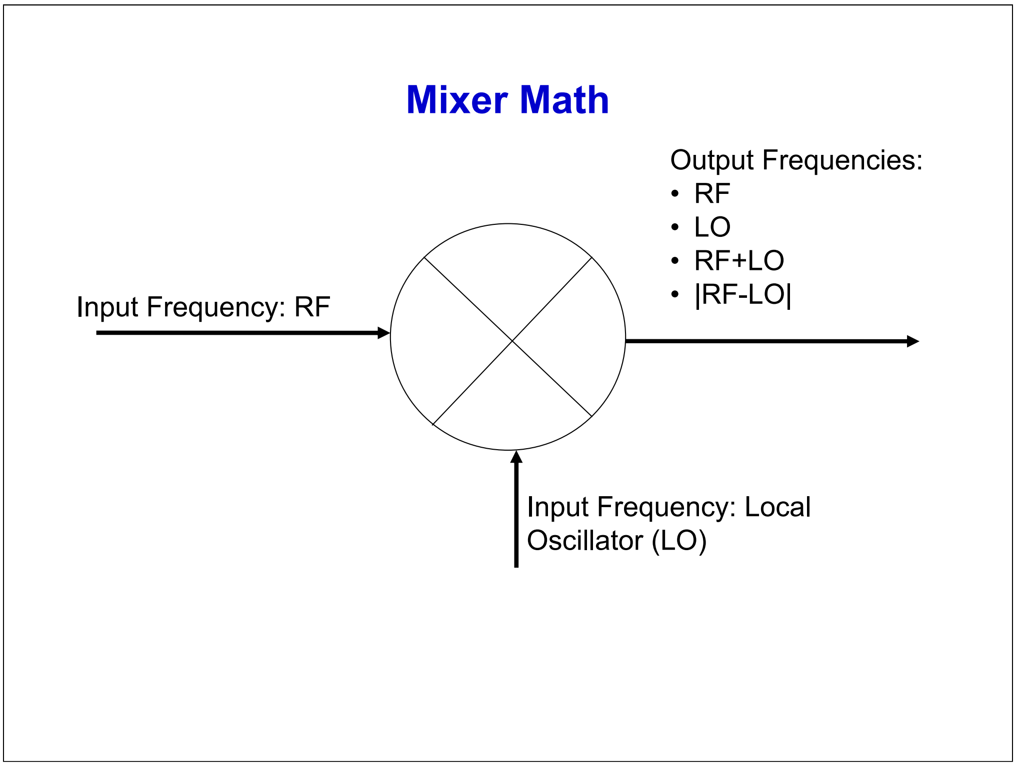
IF: The tuner output is called the intermediate frequency (IF), and it contains the same modulated information as was present at the input to the tuner. If the modulation is damaged by the tuner, the information cannot be recovered.

Filter: The IF output of the tuner is further filtered to remove all the remaining undesired energy.

IF Amp: Most demodulators need the input power to be held within a small range, so an adjustable amplifier is used between the tuner and the demodulator. Between the LNA and IF amplifier, the system adjusts its gain with the power at the input to the demodulator centered within its operational range as the power at the antenna input changes between channels and over time.

Demodulator: The last step in an RF front end is the input to the demodulator. The demodulator and later blocks are responsible for recovering the modulated information from the IF.

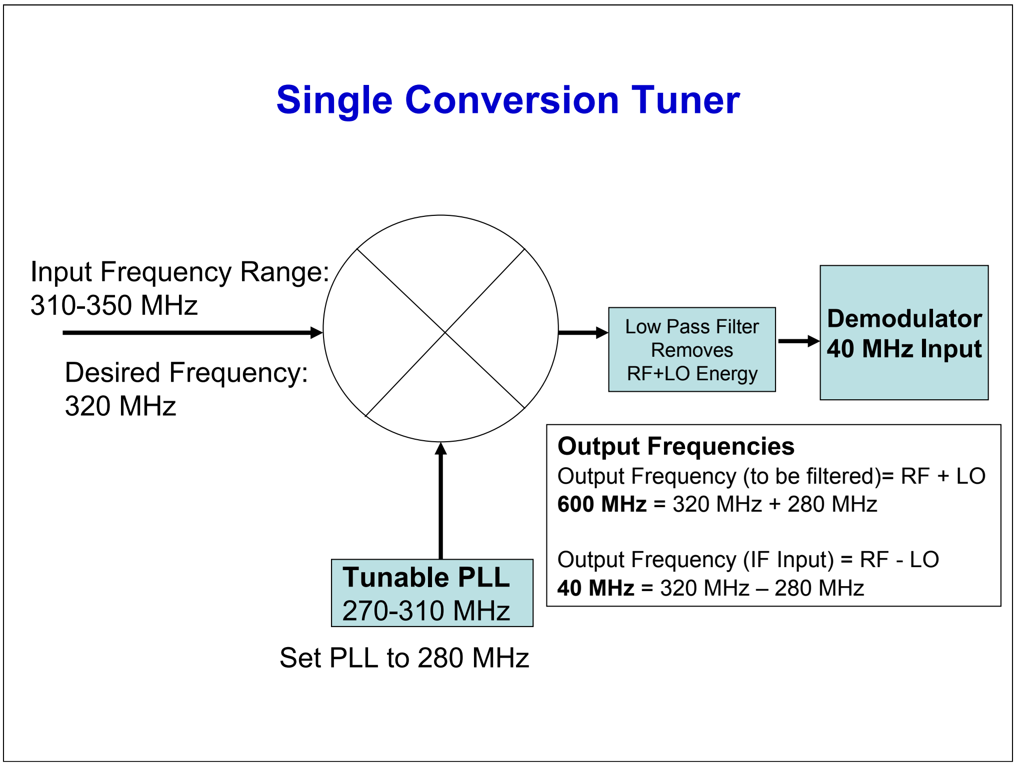
Now let's take a look at the blocks in a modern tuner. Roll your mouse pointer over each block for more information.



Now let's take a look at tuners in more detail. The mixer is the heart of the tuner. Although the math is simple arithmetic, much can be done with a mixer. The mixer generates two output signals from two input signals as well as passing the input signal.

In the radio world, the input signals are commonly called RF and local oscillator (LO). The LO signal is a clean sine wave, while the RF signal has some form of modulation applied in order to carry information. The mixer output contains the same modulation as the RF input, but at a new carrier frequency as determined by the sum or difference of the RF and LO frequencies.

The generated signals are the sum and difference of frequencies of the input signal. In most tuners, only one of the output signals is used. The modulation on the input signal is also passed through this mixer in the sum and difference outputs.

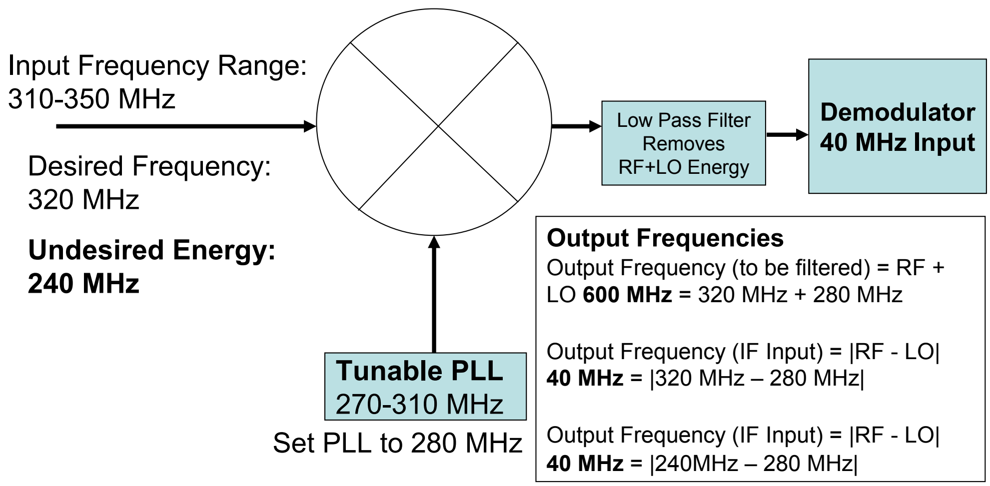


Here is an example of mixer math at work. In this system, a high-frequency RF signal input is reduced, or down converted, to a lower IF. The variable-frequency Phase Locked Loop (PLL) that generates the LO gives it the ability to tune. As different channels are desired by the user, the PLL's frequency is changed.

In this example, the desired frequency is 320 MHz, and the IF input to the demodulator is 40 MHz. Thus, the PLL must be set to 280 MHz in order to down convert the 320 MHz to 40 MHz. This example uses the difference frequency. The 600 MHz output from the mixer, the sum component, may need to be filtered before it reaches the demodulator, depending on the design of the demodulator. This type of tuner is called a single conversion down conversion because it's only using one mixer and because the input frequency is reduced, or lowered, to a lower frequency. This type of tuner was used in legacy TV sets.

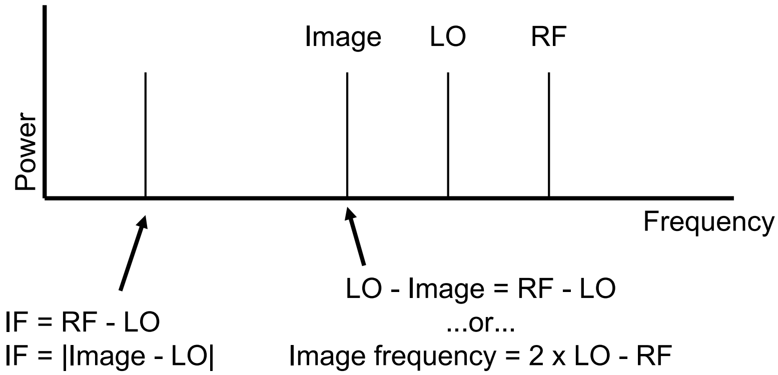
Translating the input RF signal (320 MHz) to a lower frequency (40 MHz) is called a down conversion. Using a PLL frequency (280 MHz) that is below the input frequency (320 MHz) is called low side injection.

The Image Problem



Now consider what happens with the same system if energy is present at 240 MHz. In this case, the difference product also results in a 40 MHz output at the input to the demodulator. Both 240-MHz and 320-MHz signals result in an IF of 40 MHz. If the energy is present at both frequencies at the input, the IF output will be an incomprehensible mess to the demodulator. The negative sign in the absolute value equation indicates that a spectral inversion occurs.

Image: Another Perspective



Another way to look at the problem of image is to look at a spectrum plot. In this graph, the image frequency is the same distance from the LO as the RF frequency. This also holds true with high-side injection. To prevent the image energy from reaching the IF frequency, it must be filtered before the mixer. Tracking filters are one method of removing the image energy. However, as described earlier, they are undesirable in modern electronics.

Dealing with a Poor Image

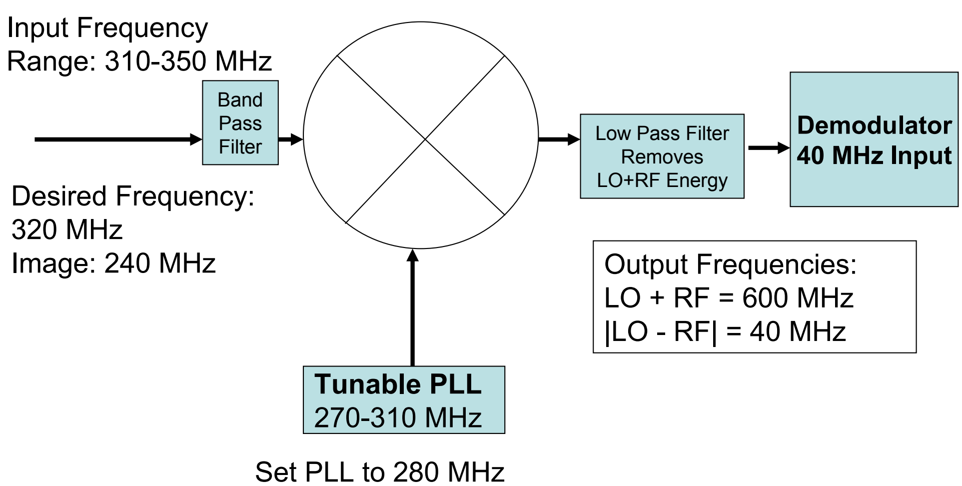
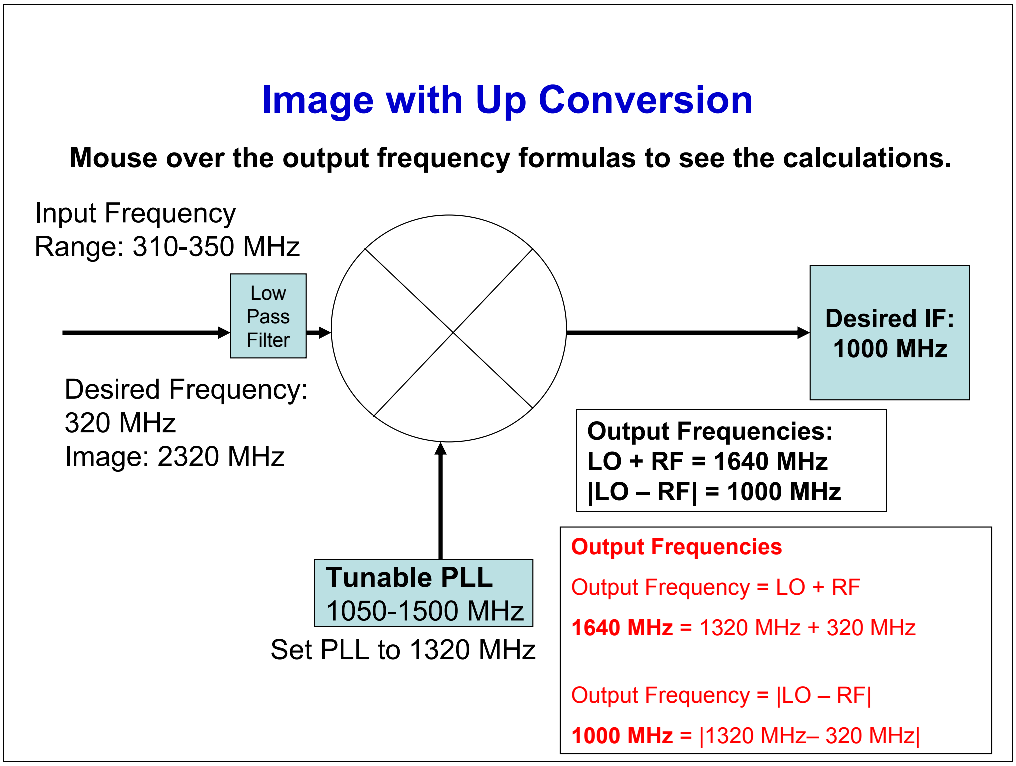


Image energy must be filtered before the mixer, otherwise it cannot be removed later. In this example, the band pass filter that allows 310 MHz to 350 MHz would do the trick. However, in a real cable system, the input frequency is much larger than the 40-MHz band shown in the example. This means a series of tracking filters would be necessary and they can be expensive and may perform unpredictably. If the image frequency can be moved further from the desired RF band, the requirements on the filter can be reduced. One way to move the image frequency is by careful selection of the IF and LO frequencies. However, this results in tighter constraints and higher costs in other parts of the RF circuitry.



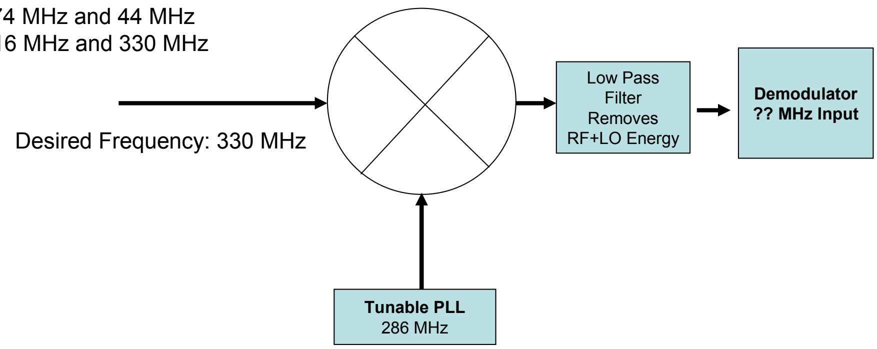
One way to reduce the requirements on the image filter is to move the image frequency far away from the desired frequency. This can be done by using an up conversion in which the desired frequency is changed to a much higher frequency. Because of the way the arithmetic works, the image frequency is far away from the band of interest, so the filter can be a simple low pass filter instead of a band pass or complex tracking filter array.

In this example, instead of converting the desired input of 320 MHz to an output of 40 MHz, the IF is going to be up at 1 GHz. In this case, our PLL is set to 1320 MHz, which means the difference frequency gives us our desired IF. However, the IF is now at a very high frequency that is impractical or probably even impossible to demodulate. So the requirements on the filter have eased, but the requirements on the demodulator have increased. Roll you mouse pointer over the output frequency formulas to see the calculations.

Question

Examine this single conversion tuner. What are the mixer output frequencies? Select the correct answer and then click Done.

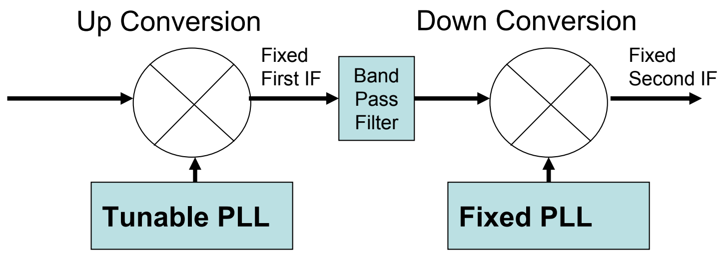
a. 616 MHz and 44 MHz
b. 330 MHz and 286 MHz
c. 374 MHz and 44 MHz
d. 616 MHz and 330 MHz



Consider this question regarding mixer math.

Correct.
The formulas for the output frequencies are output frequency = LO + RF and output frequency = |LO – RF|. Therefore the two output frequencies are 616 MHz and 44 MHz.

Dual Conversion Tuner



- First mixer up converts the signal to a frequency above the highest desired signal in the input spectrum (first IF)
- Image frequency = (2 x LO - RF)
- Band pass filter removes the second IF image frequency

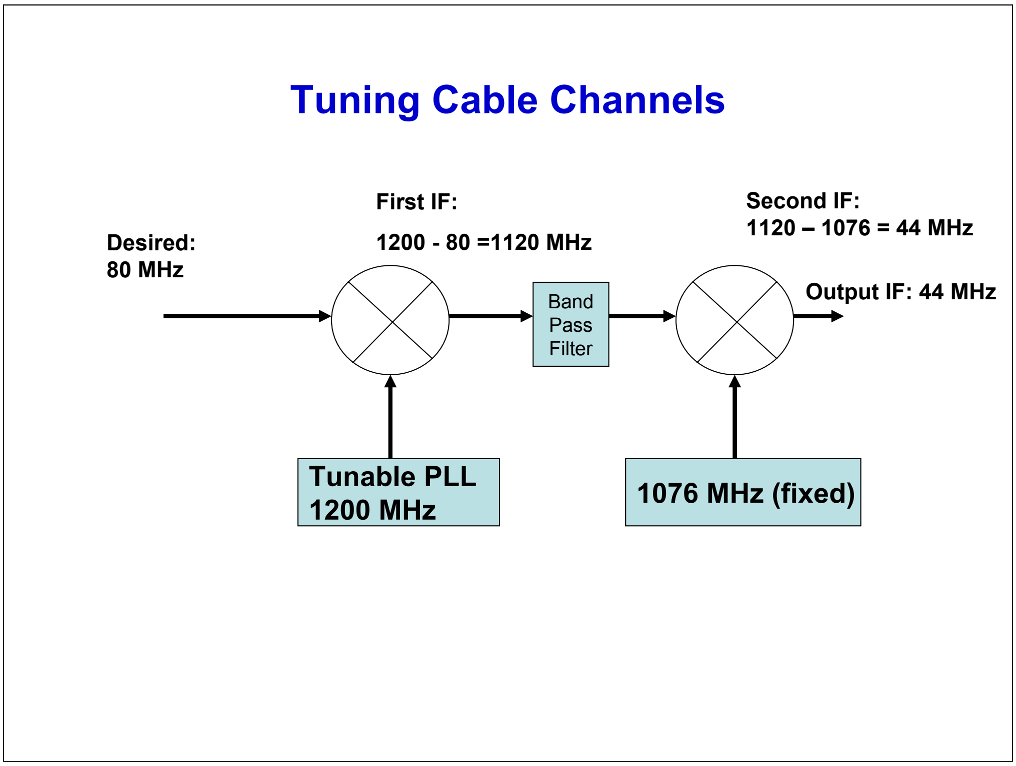
The dual conversion tuner provides an excellent method to deal with images across a wide band of input frequencies. It provides the wide image frequency separation shown with an up conversion mixer, while the following down conversion mixer provides a suitable IF for the demodulator.

The first mixer up converts the signal to a frequency above the highest desired signal in the input spectrum. The output of the first mixer is always at a fixed frequency, called the first IF.

By using a first LO that is well above the highest frequency in the input to up convert the RF, the image frequency is well above the input band. This means the filter before the first mixer is not even needed in many cases.

Because the first IF and second IF are fixed, the image frequency for the second mixer is also fixed. The band pass filter removes the second IF image frequency.

The difficulty with this tuner is the first IF and first LO are at frequencies above the highest frequency in the input band, which means the IF and LO frequencies set the system performance requirement. CMOS processes have been able to meet these requirements in a cost-effective manner for broadband applications. With a dual conversion tuner, just as you saw in the previous example with up conversion, the first IF output is at a high frequency. The second mixer brings it back down to a frequency that can be easily demodulated. This process greatly reduces the filter constraints on the front end.

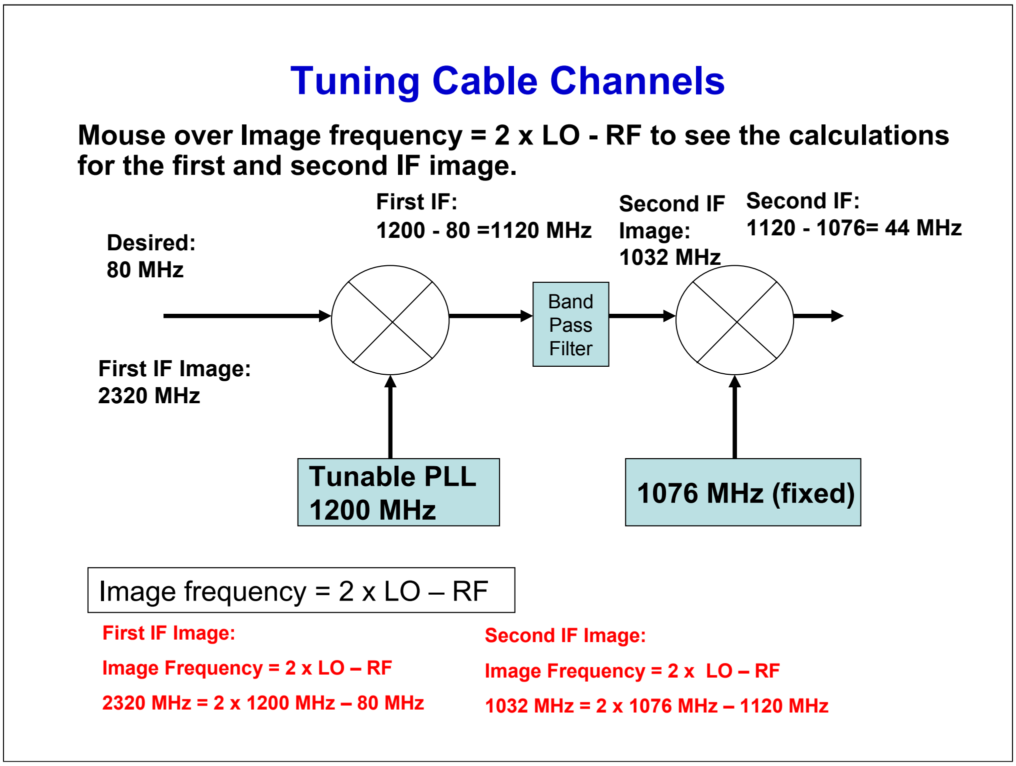


The math behind the dual conversion tuner is still simple arithmetic from the basic mixer. However, because each mixer has image frequencies associated with it, the number of arithmetic terms is much greater than in the single conversion mixer.

First we must define the channel of interest and the desired output frequency. We will assume an input channel at 80 MHz and an output IF of 44 MHz. Further, we must know the desired first IF of the system. With our tuner, the IF is 1120 MHz. Now let's work through the forward-path math to determine the LO frequencies we'll need for this configuration.

To up convert the input of 80 MHz to 1120 MHz, we'll use a first LO of 1200 MHz. Remember, we're using the difference output from the mixer. This produces our first IF of 1120 MHz.

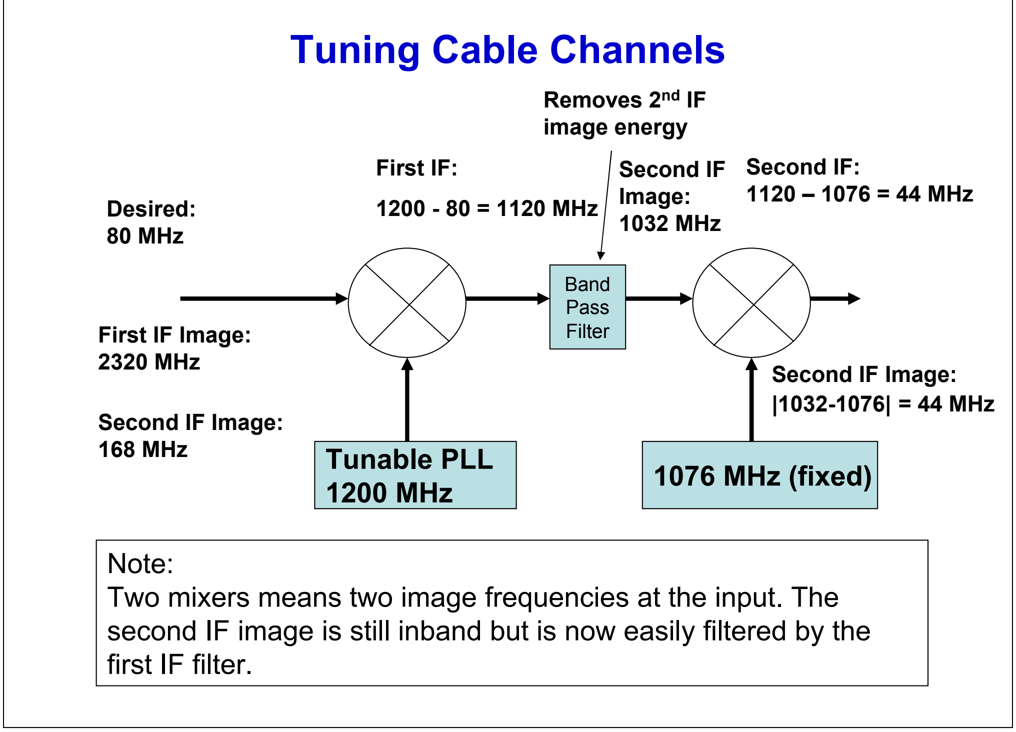
Next this IF must be down converted to the desired output frequency of 44 MHz. The second LO of 1076 MHz provides this result. Since the first IF is always 1120 MHz, the second LO does not change as the different input channels are tuned. All tuning is accomplished by changing the first LO.



Now let's consider what happens with the image frequencies in this system. In a dual conversion tuner, there are two image frequencies: one for the first mixer and one for the second mixer. The image frequencies are different depending on the part of the system, and two image frequencies exist at the input to the tuner.

Here you can see the formula for calculating the image frequency for the first mixer. In this example, the result of this equation is 2320 MHz. Thus the difference frequency, 1200 MHz minus 80 MHz equals 1120 MHz. The image frequency for the first mixer also results in an output of 1120 MHz, since 2320 MHz minus the tuned LO of 1200 also results in 1120. In cable systems, there is very little energy at this high frequency, so we actually don't need a filter in front of the mixer.

The second mixer also has an image frequency. The same formula is now used to tell us that the image frequency for the second mixer is at 1032 MHz. Again, the absolute value of 1032 MHz minus the 1076 MHz for the LO of the second mixer would result in an output of 44 MHz. Both the 1032 MHz and the 1120 MHz input to the second mixer result in a 44MHz output. Roll your mouse pointer over Image frequency = 2 x LO - RF to see the calculations for the first and second IF image.



Now let's take a look at how we can prevent energy at 1032 MHz from reaching the second mixer, and how we would actually have energy present at 1032 MHz at the input to the second mixer. The only way for energy to reach the input to the second mixer is from the output of the first mixer.

To have energy at 1032 MHz at the input to the second mixer, the first mixer must have up converted energy at its input to 1032 MHz. By remembering that the output of any mixer is its RF minus LO, we can calculate the input frequency for a desired output frequency as LO minus the mixer output. In this case, the first LO is 1200 MHz, so the result of 1200 MHz minus 1032 MHz is 168 MHz.

This means that without filters, energy at 168 MHz at the input to the first mixer will be up converted by the first mixer to 1032 MHz. Since 1032 MHz is the image frequency for the second mixer, the 168 MHz at the input to the tuner is an image frequency for the second mixer. The advantage of the dual conversion tuner is that the second LO is fixed in frequency, which means that its image frequency is also fixed. That's the 1032 MHz.

In a broadband system, energy is almost always present at 168 MHz because there are so many channels. It’s almost guaranteed that the first up conversion will result in image energy at 1032 MHz. We must use a filter between the mixers to remove that energy; otherwise, the resulting output IF will be unusable.

Another advantage of the dual conversion tuner is that the second LO is fixed in frequency, which means that its image frequency is also fixed. Therefore, the filter to remove the image frequency is also a fixed-frequency device and tracking filters aren’t necessary. The filter between the mixers accomplishes the work that was done by the tracking filters in the single conversion tuner. The band pass filter only needs to be wide enough to pass the signals of interest.

One minor problem is that in the tuner, the first IF actually does move around a little bit. Due to the use of a 25 MHz reference frequency, the first PLL tuning steps are made in 25 MHz steps. Since TV channels are spaced 6 MHz apart in the U.S., the first IF is actually not always centered on 1120 MHz: the wide band is actually about 30 MHz. To account for these small shifts in frequency, this tuner’s second LO is also tunable. The band pass filter must be wide enough to account for the range of these possible first IFs (about 30 MHz).

With a dual conversion tuner, a wide range of input frequencies can be selected without the use of temperamental manually tuned tracking filters. A single band pass filter between the mixers replaces the tracking filters used in the old tuner designs. Today, the band pass filter is usually a surface acoustic wave (SAW) filter, which has performance characteristics similar to those of modern semiconductors. The advent of advanced silicon processes that can support the high first IF frequency enabled the creation of cost-effective dual conversion tuners.

Question

What are the roles of the two mixers in the dual conversion tuner? Select the response that applies and click Done.

a. The first is a down conversion mixer that provides wide image frequency separation, while the second is an up conversion mixer that provides a suitable IF for the demodulator.

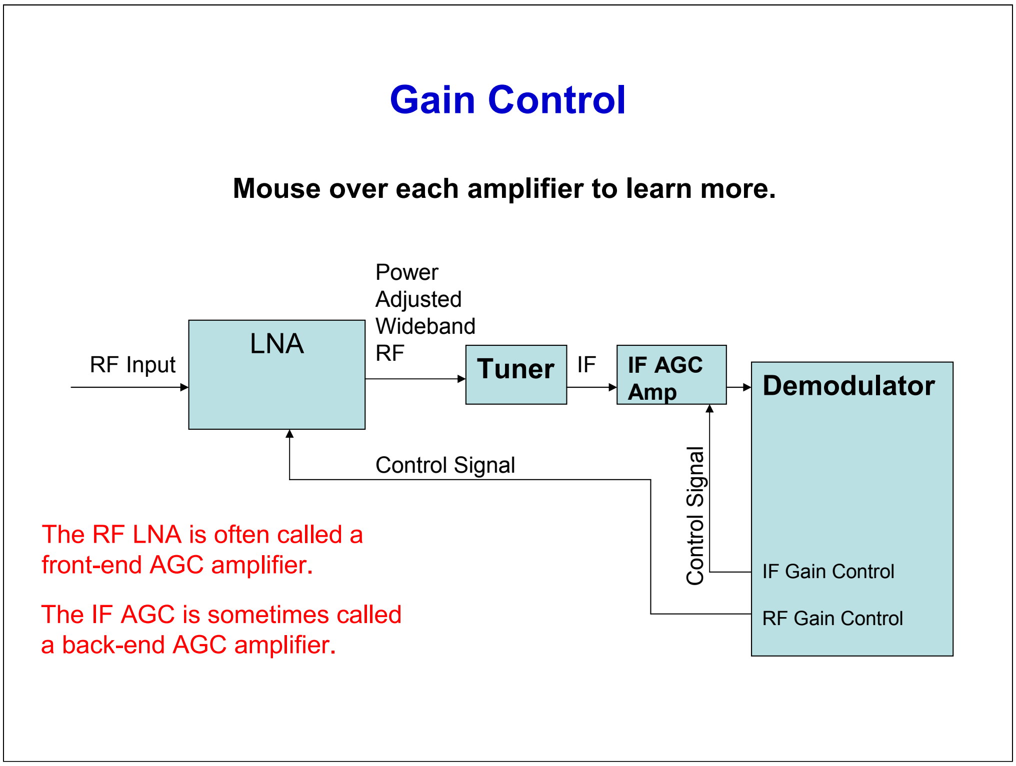
b. The first is an up conversion mixer that provides a suitable IF for the demodulator, while the second is a down conversion mixer that provides wide image frequency separation.

c. The first is an up conversion mixer that provides wide image frequency separation, while the second is a down conversion mixer that provides a suitable IF for the demodulator.

Consider this question regarding the dual conversion tuner.

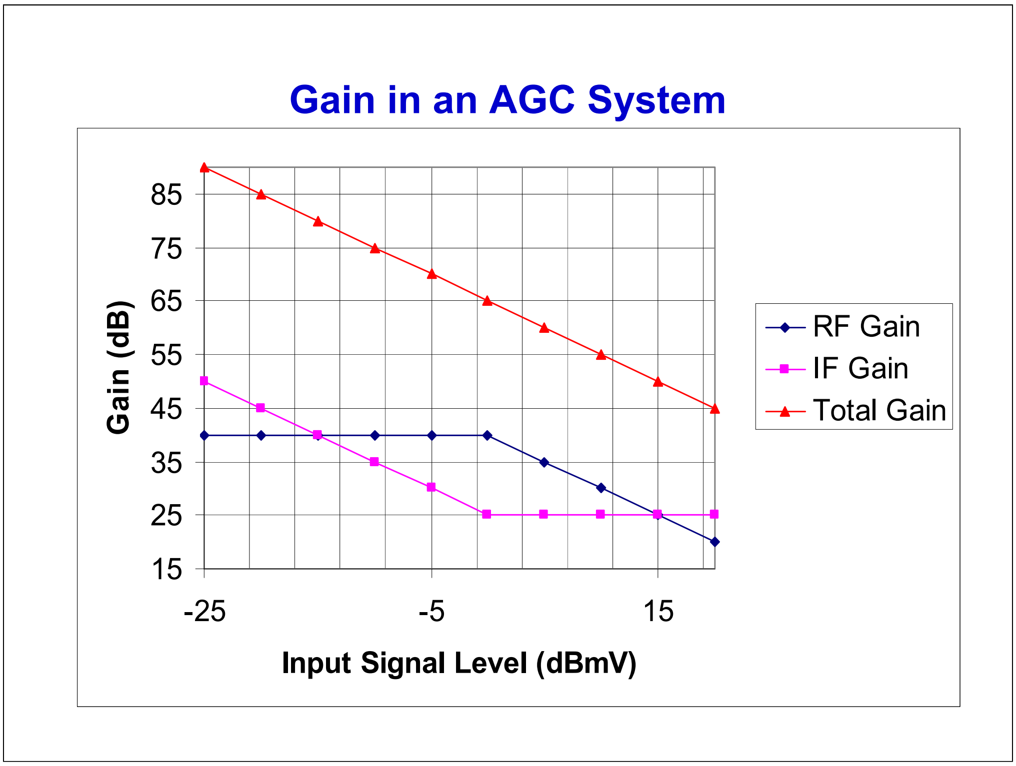
Correct.

The first mixer is for up conversion, and it provides wide image frequency separation, while the second mixer is for down conversion, and it provides a suitable IF for the demodulator.



Another aspect to consider is the gain control. The demodulator requires the power of its input signal to be in the middle of its analog-to-digital converter's range. Since input power can vary dramatically from channel to channel, day to night, and season to season, a level adjusting system is needed.

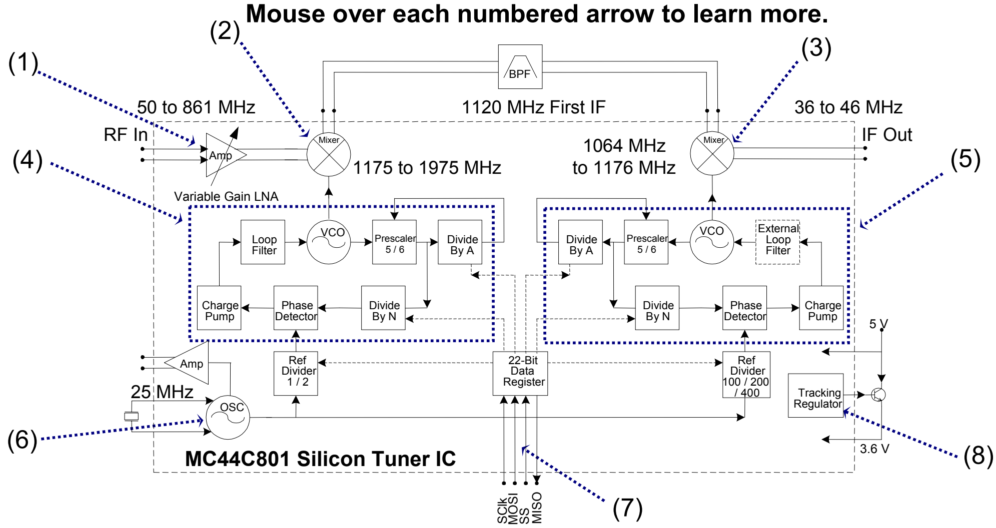
The traditional method is to have an adjustable gain stage before the tuner and an adjustable gain stage in the IF path. The demodulator provides an analog signal output that adjusts the gain of the amplifiers. Analog filters are used to determine which gain stage is adjusted. In this type of system, overall gain adjustments of 40 to 60 dB are possible, and either the RF LNA or the IF Automatic Gain Control (AGC) amplifier actively adjusts power. The RF input power that corresponds to the switch between the RF Gain Control and the IF Gain Control is called the attack point. Roll your mouse pointer over each amplifier for more information.



Here you can see a system with what's called a 0 dBmV attack point. When the RF input power is very low, the RF front-end AGC gain is at maximum. As the input power rises, the IF AGC gain is reduced. At 0 dBmV, the IF gain is reduced to its minimum value. Above 0 dBmV, the IF gain is held constant while the RF gain is reduced. The choice of the attack point is a system design issue based on the overload characteristics of the various gain stages. This choice allows for the best noise figure for low-level signals while maintaining good performance with high-level signals. This approach is commonly called delayed AGC.

MC44C801 Silicon Tuner IC

Mouse over each numbered arrow to learn more.



(1) Integrated variable gain LNA with 21dB of programmable gain control (2) Up conversion mixer (3) Down conversion mixer (4) Fully integrated first VCO and loop filter (5) Second VCO requiring only an external inductor (6) On-chip reference oscillator (7) SPI interface bus (8) On-chip voltage regulator

Let's look at Freescale Silicon Tuner products. Here you can see a block diagram of the Gen2 Silicon Tuner IC, part number MC44C801. This is a dual conversion tuner. In simplest terms, this device takes in RF signals in the 50 MHz to 861 MHz range and converts them to an IF between 36 MHz and 46 MHz for output. The standard IF frequency used in North and South America as well as South Korea is 44 MHZ to 45 MHz; 58 MHz in Japan, and 36 MHz to 39 MHz in the rest of the world.

Roll your mouse pointer over each numbered arrow to learn more about the MC44C801's features.

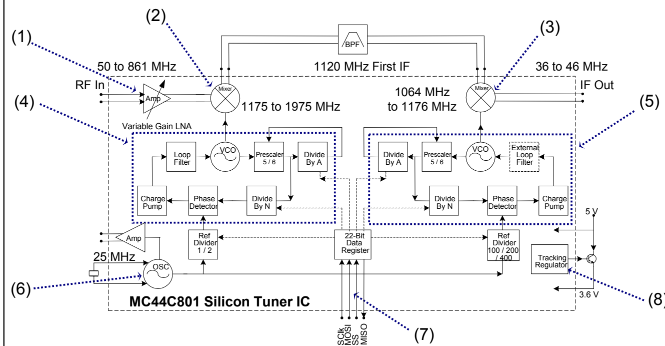
The MC44C801 is driven by an external single 5V supply and a 25-MHz crystal. The on-chip 22-bit data register is set with predetermined system values via the serial peripheral interface (SPI) interface bus.

RF signals in the 50 MHz to 861 MHz range are input to the device. At this point, a predetermined amount of gain is added to the signal via the variable gain LNA. As the signal reaches the up conversion mixer, it is mixed with input from the first LO. The signal is up converted to a frequency in the 1120 MHz range and sent off chip to an external filter. In this example, the external filter is a 1120-MHz SAW filter. This eliminates any unwanted images, making further processing much easier. The signal is brought back on chip to pass through the down conversion mixer with input from the second LO. Now, the IF signal is in the 36 MHz to 46 MHz range, and it is output from the chip for further system processing.

Using this device has significant benefits. The integration surrounding the two LOs (VCO 4 and 5) eliminates the need for additional costly, precision components. The MC44C801 device has also eliminated the need for high voltage (30V) and analog (9V) supplies.

Click "MC44C801" to see an enlarged view of this block diagram.

MC44C801



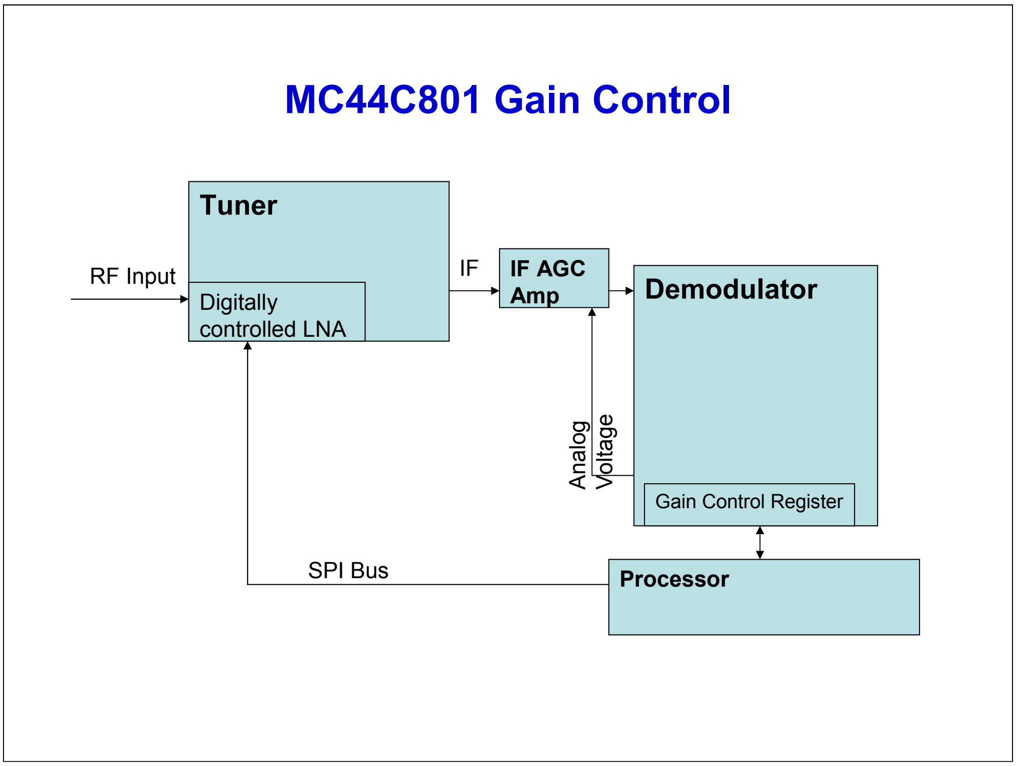
(1) Integrated variable gain LNA with 21dB of programmable gain control (2) Up conversion mixer (3) Down conversion mixer (4) Fully integrated first VCO and loop filter (5) Second VCO requiring only an external inductor (6) On-chip reference oscillator (7) SPI interface bus (8) On-chip voltage regulator

MC44C801 Key Performance Specs

Parameter	MC44C801
Frequency Range	50 to 861 MHz
Conversion Gain	38 dB
Gain Control Range	21 dB
Noise Figure	<6 dB
CSO	@-4 dBmV, -66 dBc
CTB	@-4 dBmV, -63 dBc
Cross-modulation	@-4 dBmV, -58 dBc
Passband Gain Flatness	± 0.5 dB
Sideband Noise @ 10 kHz	–94 dBc/Hz

Here are some important performance specifications for you to remember because they can demonstrate to customers how the MC44C801 can be valuable in their implementations.

Let's highlight some of these features. The frequency range provides support for the majority of TV channels. The key performance figures of the MC44C801 are its noise figure, CSO and CTB. In today's environment, a CSO and CTB of greater than 60 dB is very good; in fact, it is required in the majority of current tuning systems. The MC44C801 exceeds this requirement and provides the functionality and performance specifications that customers look for when trying to solve this portion of a system design.



In the MC44C801 dual conversion silicon tuner, a digitally controlled LNA is included in the front end. The LNA can be programmed through the SPI port to provide between -9 dB and +12 dB of gain.

Unlike the traditional analog AGC approach, a microprocessor is involved in the AGC process. In this system, the demodulator controls the back-end IF AGC through the standard analog method while the processor controls the front-end AGC. The processor is able to calculate the input power of the two channels and then set the front-end gain appropriately. A combination of laboratory and factory calibration makes this method work.

For a given design, each of the contributors to gain variation can be measured and calibrated in the lab. For example, the front-end gain is known by the set point applied to it. The tuner and IF gain can be measured and compensated for, if necessary. IF AGC amps are usually operated in the linear range so the processor can determine the gain of the AGC amp by reading the demodulator's gain control register.

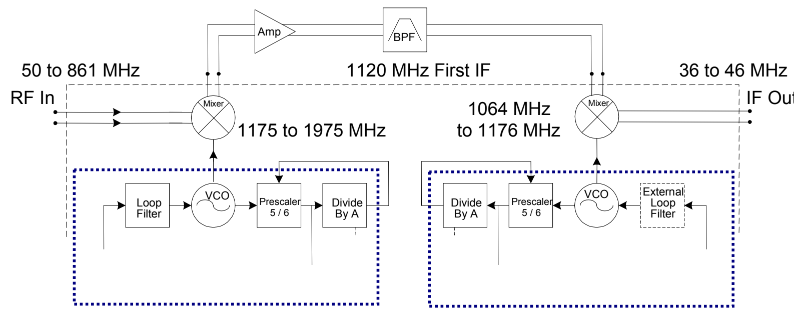
The end result of all of these measurements and calibrations is that the processor can infer the input power by knowing the LNA setting, AGC control register value, tune frequency, and mixer settings. This technique has been successfully used to meet DOCSIS 2.0 requirements of +/- 3 dB of accuracy for power measurements. A version of this power management software is delivered with the evaluation kit (EVK).

Question

Does this block diagram accurately represent how RF signals flow through the MC44C801? Click Done when you are finished.

Yes

No



Done

Here is a question to check your understanding of RF signals and the MC44C801 tuner.

Correct!

This diagram does not accurately represent the MC44C801. In the MC44C801, the variable gain LNA is located between the RF In and the first mixer.

SPI Interface Bus

- Very straightforward
- Many controllers do not have hardware support for SPI because it is so simple
- 4 GPIO lines are used to implement
- Very simple code
- Multiple tuners can share the bus, requiring 1 more GPIO for each additional device
- Fast, 10 MHz clock

The SPI interface bus is used to communicate with the silicon tuner. All the programming for channel changes and gain settings are done over the SPI interface. It is so straightforward that most microprocessor controllers don't have hardware support for them, but it's very easy to implement using just four general-purpose input-output (GPIO) lines.

Click “SPI Code” to see the main section of code.

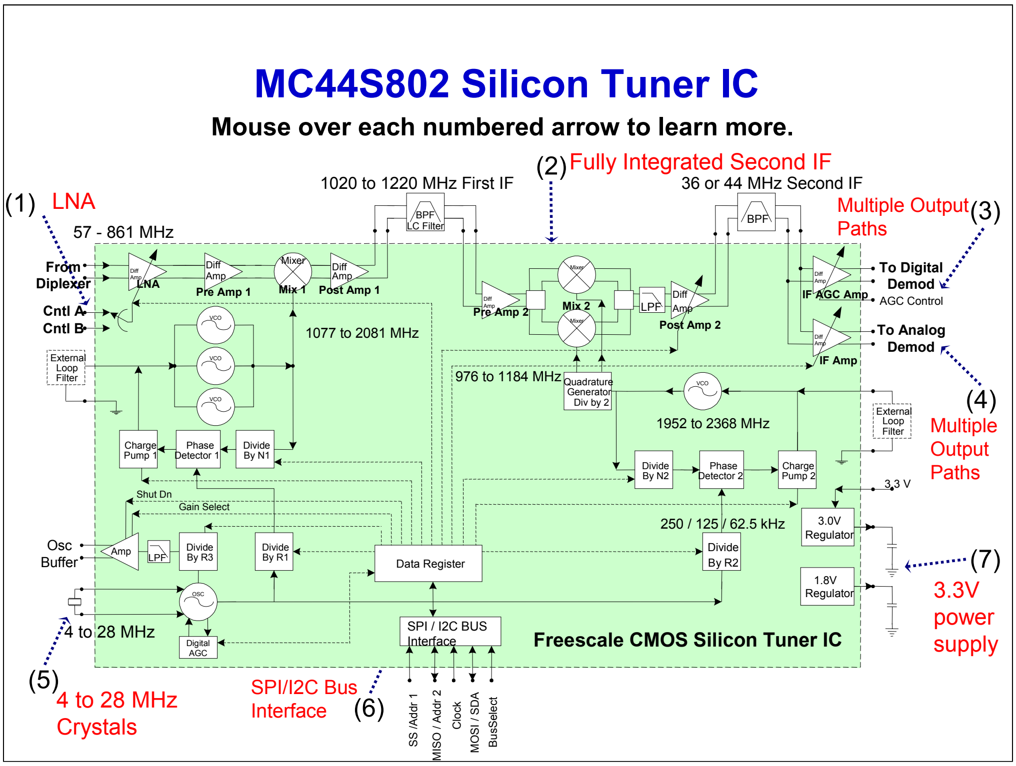
Multiple tuners can share the bus, requiring one more GPIO for each additional device. The SPI interface bus is also very fast, with a 10 MHz clock.

Some customers want an I^2C bus rather than the SPI bus because that's what they're currently using, but as you can see, the lack of an I^2C should not prevent them from using the MC44C801 because the SPI is not difficult to implement. They don't actually have to write the code to support the SPI bus because Freescale provides it. The application note "SPI Implementation for the MC44C801 Silicon Tuner IC" provided in the EVK has more information.

SPI Code

This is the main routine for communication back and forth between the processor and the tuner, though other code is used for initialization.

```
unsigned long spi_rxtx (unsigned long txword, int
      len){
   int cntr;
   unsigned long read;
   int nop;
   read = 0;
   txword = txword << (32 - len);
   g_imm->pp.PADAT |= (SPI_CLK);
   g_imm->pp.PADAT |= (SPI_SEL);
   for (cntr = 0; cntr < len; cntr++) {
      if (txword & 0x80000000){
         g_imm->pp.PADAT &= ~(SPI_TX);}
    else {
         g_imm->pp.PADAT |= SPI_TX; }
      read = read << 1;
        for (nop = 0; nop < 1; nop++);
      g_imm->pp.PADAT &= ~(SPI_CLK);
      if ((g_imm->pp.PADAT & SPI_RX) == 0){
         read |= 0x0001; }
      for (nop = 0; nop < 1; nop++);
    g_imm->pp.PADAT |= SPI_CLK;
      txword = txword << 1;
   }
   read = read << 1;
   g_imm->pp.PADAT &= ~(SPI_SEL);
  return (read);
}
```



Here you can see a block diagram of the Gen3 Silicon Tuner IC, part number MC44S802. This is a dual conversion Silicon Tuner with integrated IF AGC amp. The MC44S802 builds off of the MC44C801 functionality with several enhancements.
Roll your mouse pointer over each numbered arrow to see some of these enhancements.

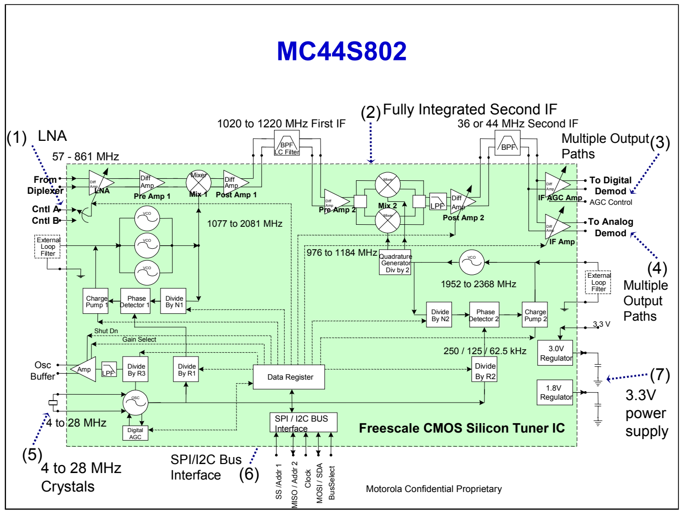
With regard to front-end improvements, the LNA has been improved with reduced gain roll-off. The gain control range has been modified to support either 40 dB or 60 dB of gain control. Users can implement analog or digital gain control, and they can also switch between these two AGC control systems for use in dual-demodulator systems.

The fully integrated second IF provides multiple output paths for the down converted IF signal, again for the benefit of dual demodulator systems. The two paths provided are via an IF AGC amp to the digital demodulator and via an IF amp to the analog demodulator. The benefit of this integrated feature is that it enables customers to develop more cost-effective systems. With the addition of this feature, users don't have to provide this functionality off chip and thus add expense to their overall bill of material.

Another enhancement is that customers can program the device via an I^2C interface bus as well as the SPI interface.

Finally, the MC44S802 can be implemented with crystals that range from 4 MHz to 28 MHz, and it works off of a single 3.3V power supply.

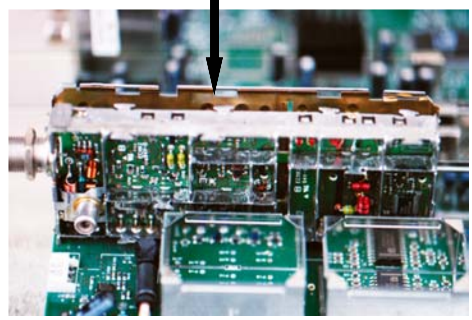
The biggest benefit to users of the MC44S802 is that its power consumption has been reduced significantly from the previous MC44C801 product. The MC44S802 consumes approximately 800mW of power , and implementing an external IF amp can further reduce power use to about 500mW.
Click “MC44S802” to see an enlarged view of this block diagram.


MC44S802
(1) LNA
57 - 861 MHz
From Diplexer
Cntl A
Cntl B
External Loop Filter
LNA
Diff Amp
Pre Amp 1
Mixer
Mix 1
Diff Amp
Post Amp 1
1020 to 1220 MHz First IF
BPF
LC Filter
(2) Fully Integrated Second IF
36 or 44 MHz Second IF
Pre Amp 2
Mix 2
LPF
Diff Amp
Post Amp 2
BPF
Multiple Output Paths (3)
IF AGC Amp
To Digital Demod
AGC Control
IF Amp
To Analog Demod
(4) Multiple Output Paths
1077 to 2081 MHz
VCO
976 to 1184 MHz
Quadrature Generator Div by 2
1952 to 2368 MHz
Charge Pump 1
Phase Detector 1
Divide By N1
Divide By N2
Phase Detector 2
Charge Pump 2
External Loop Filter
3.3 V
Shut Dn
Gain Select
3.0V Regulator
1.8V Regulator
250 / 125 / 62.5 kHz
Osc Buffer
Amp
LPF
Divide By R3
Divide By R1
Data Register
Divide By R2
(7) 3.3V power supply
OSC
Digital AGC
4 to 28 MHz
(5) 4 to 28 MHz Crystals
SPI / I2C BUS Interface
Freescale CMOS Silicon Tuner IC
SPI/I2C Bus Interface (6)
SS /Addr 1
MISO / Addr 2
Clock
MOSI / SDA
BusSelect
Motorola Confidential Proprietary

Silicon Tuners vs. CAN Tuners

MC44C801

CAN Tuner



Silicon tuner benefits:

- No tracking filters, thus no manual tuning
- Improved temperature response
- Improved aging performance
- Lower manufacturing costs
- Can be integrated on main board
- Lower cost

Here you can see the MC44C801 as implemented on a reference card and a CAN tuner. The silicon tuner, which is a dual conversion tuner, has many benefits over a CAN tuner. No tracking filters are required, so no manual tuning needs to be done. Silicon tuners have improved temperature response as well as improved aging performance.

Operating the device within temperature and over time, has no impact on a silicon tuner compared to a CAN tuner, which will suffer from both of these conditions.

The silicon tuner can be integrated on the customer's main board, whereas you can see from the lower right-hand picture of the implementation of the CAN tuner, it's implemented as sort of a daughtercard, perpendicular to the PCB plane itself. Implementing a silicon tuner IC instead of a CAN tuner will ultimately lower the cost of implementation, not only from the components perspective but from the reduced manufacturing manpower.

Question

What are some of the enhancements of the MC44S802 compared to the MC44C801? Select all that apply and then click Done.

Significantly smaller footprint

Second IF provides multiple output paths for the down converted IF signal

Faster signal conversion

Customers can program the device via an I^2C interface bus as well as the SPI interface

Greatly reduced power consumption

Done

Please select all the statements that describe the enhanced features of the MC44S802 compared to the MC44C801.

Correct.

The MC44S802 has a second IF that provides multiple output paths for the down converted IF signal, customers can program the device via an I^2C interface bus as well as the SPI interface, and greatly reduce power consumption. These features are all enhancements not available on the MC44C801.

Course Summary

- CAN tuners (single conversion)
- Silicon tuners (dual conversion)
- Advantages of using silicon tuners
- Applications for silicon tuners
- Single conversion and dual conversion tuners
- MC44C801 Silicon Tuner IC
- MC44S802 Silicon Tuner IC

In this course, you learned that tuners receive audio/video programming via an RF broadcast, then select and convert a single signal into a lower, more workable frequency. Silicon tuners are highly integrated circuits that provide this functionality in a single chip as opposed to the short-lived, more expensive CAN tuners. Silicon tuners can be used in Cable modems, CATV set-top boxes (analog and digital), CATV Media Gateway, and Computer TV tuner cards (analog and digital). You also learned about the advantages of dual conversion tuners, which don’t use tracking filters like single conversion tuners.

Finally you learned about the MC44C801 and MC44S802 tuners, which have lower costs, lower power consumption, and superior performance in areas such as CSO and CTB as compared to the competition.