Steve's Scanner Shop

NEW Mod For Digital

Decoding Digital Signals Made Easy

By Steve Donnell

More and more these days both voice and nonvoice forms of radio communications are being sent as digital FSK(Frequency Shift Keying) signals. Some of these are what are known as "two level" signals, where the radio signal shifts plus to minus or minus to plus a fixed amount of offset from the center frequency of the radio channel to represent digital binary numbers that make up the data stream. Examples of these types of signals would be the control channel of a Motorola or EDAC trunked radio system, or an ACARS text message systems used by commercial airlines. The circuitry needed to convert a scanner's FM detector baseband signal into something that can be recognized by a computer's serial port is fairly simple, and many examples of these can be found on various Web sites.

Long time readers of *Scanning USA* may also recall as to where we were the very first to highlight that Trunktrack scanners such as the BC245 and BC780 have their own internal slicers that are used to allow the scanner's own internal computer to follow trunked radio systems. Tapping into the scanner's internal slicer, permits an almost effortless way directly interface the scanner to a PC in order to run programs such as Trunker.

A more complex form of digital transmission is a modulation format known as a "4_level" signal. As the name implies, instead of just two different level states(or phases to be more accurate), there are four different ones; two plus(4 KHz and 2.5 KHz) from the center frequency, and two below(4 KHz and 2.5 KHz) from the center frequency. Good examples of a four level digital signal would be a Motorola "Project 25" transmission as well as certain text protocols such as (high speed)FLEX. Construction of an interface for use with four level signals is far more complex than what is needed for a mere two level signal format.

While there have been several variations of four level interfaces described on the Web and in other publications, from what I can see they are all based on the same design that is centered around two albeit readily available and low cost ICs: one quad(4 in 1) operational amplifier and one quad comparator chip. The only real variations that I have noticed are that one design uses a simple voltage "inverter" chip in order to supply a negative DC power supply voltage, instead of relying on two different(or one center tapped) power transformers. In operation, the comparators sense the voltage level which corresponds to the frequency offset of the transmission at a given instant, and they produce a logic output which ties in to the computer's serial port to be read by a particular decoder application program.

Very early on we had recognized the close similarities between how the comparators are configured in the existing four level slicer circuit to that of a circuit found in a very old Radio Shack project book(from about twenty five years ago) which used the very same comparator chip to function as a simple volt meter that used a string of LEDs to indicate a given voltage level. A few years later, National Semiconductor introduced a somewhat more sophisticated version of this same circuit with their LM_3914 series ICs. These chips were specifically designed for use as LED bargraph drivers.

The displays produced from these chips could be selected to operate in either typical bar graph or "moving dot" format, and variations of the chips were available to produce outputs with either linear or log scale steps. Japanese variations of these chips quickly found their way into many types of consumer electronics equipment as solid state replacements to older mechanical meters used for displaying received signal strength or audio VU units in a wide range products sold during the nineteen eighties.

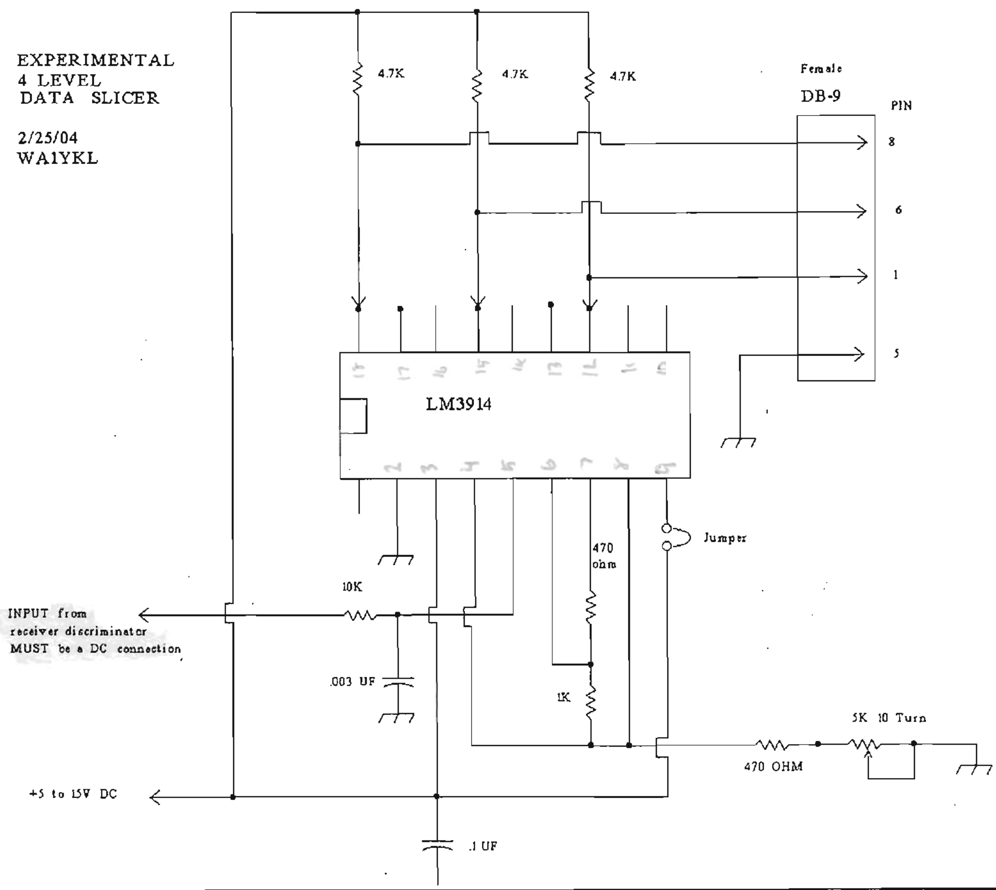
I began to wonder if there was a way to use one of these LM_3914 chip to produce the same type of (logic)output signal(s) as produced in the more complex four level slicer circuit. I started to experiment with a circuit based on one of the examples I found in the Application Notes from National Semiconductor for a simple "expanded scale LED volt meter". This circuit would produce an output using an LED scale based upon a narrow window of high or low differences in a voltage level seen at the input of the chip, against an adjustable reference(voltage) level. In sharp contrast to existing designs of four level slicer circuits, this one needs only one IC, and requires only about a quarter the number of resistors and capacitors, and can be operated from a single polarity DC power source, without the need of a regulator, and can easily be made small enough to fit inside many scanners.

It should also be noted this circuit can also be used as a very effective two level slicer as well. While this circuit should work quite well with signal from the FM detector, otherwise known as a the "discriminator" of nearly any scanner, one very important requirement needs to be met first: The connection to the scanner's discriminator needs to be done using a resistor, and not with a capacitor as is commonly noted in other Web and published scanner modification notes. Of course if you have been following our recommendations for installing scanner discriminator "tap" mods, then you likely already have done your mod using a 2 to 4 K ohm value resistor. Using a resistor provides the same function as a capacitor in that it protects the scanner's FM demodulator IC from having the discriminator output being accidentally shorted to Ground.

The main advantage that we have seen in using a resistor, you are far less likely to introduce distortion of the waveform of the data signal. This is particularly true with very low frequency signals such as DCS/DPL or LTR data signals. For example, a "tone reader" box such as an Optoelectronic DC440 has a much harder time displaying a DCS code from a scanner with a capacitor coupled discriminator, than from one with a resistor tap. In addition, if you were to construct any type of frequency error/offset meter displays, a discriminator tapped with a capacitor would not provide the same DC offset value that would be needed.. The philosophy that I have always stayed with in this matter, is to bring the discriminator signal out of the scanner in it's purest, most original form. And if you need or wish to "DC block" it later for a given use, then fine.

The whole idea as to how this circuit operates is the comparator string/stack needs to be able to "read" the instantanious DC voltage value produced from the scanner's discriminator. The only real drawback in a slicer that uses the DC value from the discriminator is that in order to use the same circuit with more than one scanner, you will likely need to readjust the calibration reference point. However seeing as how simple this circuit is to make, then it is just as easy to construct more than one of these interfaces. If you decide to construct this circuit so that it resides inside your scanner, then you may connect the 10K resistor from the circuit directly to the discriminator output pin of the IF Demod IC, and leave the existing resistor(or capacitor) in place to connect the discriminator to the outside world.

It is also important to note that this circuit functions quite well as a two level slicer. All that you need do is use the output from pin 15 on the chip, and connect it to whatever RS232 pin(usually either 6 or 8) that your particular application program requires. A few additional construction and setup notes are in order here: The jumper that is included at pin 10 is how the chip is selected to operate in either "bar graph" or "moving dot" modes. Normally the jumper should be left in place(pin 9 tied Hi). However some future application may come along where it would be better to have a different output data pattern where only one line



at a time is Low.

Additionally, in order to decode future (more narrow?) modulation formats it may be necessary to use some of the other output lines on the chip for determining the slice points of the data "rails". Instead of using pins 12 and 18, it might be necessary to use pins 13 and 17. And finally, while it's best to use a 5 or 10 turn "multi turn" 5K ohm trim "pot" for variable resistor that is used to calibrate the slicer, you can use a more common single turn pot here, but the calibration may be a bit trickier to do and more subject to drift. Actual calibration of the circuit is simple: Measure the voltage at the input(pin 5) WITH a signal being received. Then adjust the 5K trim pot so that the voltage on pin 6 of the IC equals the voltage measured at pin 5, plus .400V(400 mv).

You may need to fine tune this a bit closer, depending upon the alignment and tuning calibration of the scanner being used. If you have access to an oscilloscope, the output waveform on pins 12, 15, and 18(while receiving a 2 or 4 level signal) should look like a fairly uniform square wave. When NOT receiving any signals, the outputs at pins 12 and 18 , appear to have random noise on them, however they will appear to be inverted to each other; with one edge(or rail) fairly "flat" and the other slightly ragged. In closing there are a couple of caveats that should be carefully noted: This is merely an "experimenter's circuit"and is subject to future development by myself and possibly others. While I have done a certain amount of testing of this circuit, I honestly do not know if this interface produces the same logic states/symbols as is produced from the other four level circuit.

Although tests using applications such as Trunker, and other programs seem to indicate that it does. My primary intent in bringing this circuit into the public domain is to provide an additional (hardware)option for those who may be interested in developing PC applications for decoding of Project 25 voice and or Network Access Codes. Not to mention that as these programs become available there will be an even greater demand for a simpler way to interface four level digital signals into a PC than is currently the case. It should also be carefully noted that use of this interface in connection with some programs for decoding of various types of digital transmissions may be a violation of the law, depending upon where you live. Check the laws that apply in your community and consult with a lawyer if you have any doubts. I am not responsible if you misuse this circuit in any way.