A Technical and Critical Analysis of the F-scan

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Abstract

The F-scan is a medical device which claims to scan the body and detect "resonances" of pathogens. In this way it purports to identify such pathogens in the body and provide treatment of the same by way of electrical frequencies applied via pads to the skin using principles attributed to Dr Royal Raymond Rife and Dr Hulda Clark. The machine is also described as a highly accurate precision frequency generator. Having examined the claims made for this device, and in particular, having examined and tested the device itself, I conclude that it cannot possibly do what it claims to do and that even its stated electrical specification is incorrect and misleading. This paper is a technical report in which I will explain the real operation of the device and its real specifications as measured in tests.

Device Specifications and Claims

I will address some particular specifications and claims that are made for the device by its manufacturer. I have not addressed every claim, only the major ones I believe are incorrect and/or misleading and I have limited comments to technical claims, not ones based upon medical theories of Rife and/or Clark. Advocates of such techniques may find that the machine does not meet the generally accepted specifications of either of these therapies.

1. Frequency Outputs

The device has two independent frequency outputs labelled OUT1 and OUT2 respectively.

The OUT1 output claims to produce a sine wave of 10V or 1.3V amplitude peak to peak (switch selectable) which is positively DC offset.

A separate switch claims to produce a constant 5v rectangular wave from the same output.

The OUT2 output is claimed to produce a "rectangular wave", variable in amplitude between 0 and approx 27V DC, it is claimed that another switch allows selection of a true AC output or half the AC amplitude with positive DC offset.

The device was connected to a standard, calibrated 20Mhz oscilloscope using a 10x Tectronix probe properly balanced for the bandwidth of the oscilloscope. The probe impedance was 10MOhm. The oscilloscope and probe was tested with a professional frequency generator and found to be accurate and in good working order.

The output from OUT1 of the F-scan was displayed on the oscilloscope at various frequencies. The waveform was observed to be seriously distorted. It contained massive harmonic distortion and in fact could not be truly described as a sine wave.

In particular, two features of the distortion were very obvious:

a) The “sine wave” had a sharp peak at the top, reminiscent of a triangle wave.
b) The wave was “jagged” in distinct steps on the rising and falling edges.

And a third less obvious but nonetheless visible distortion is high frequency quantization “hash” in the entire wave (fine serrations).

Figure 1 shows a photograph of the oscilloscope trace of the wave in question.

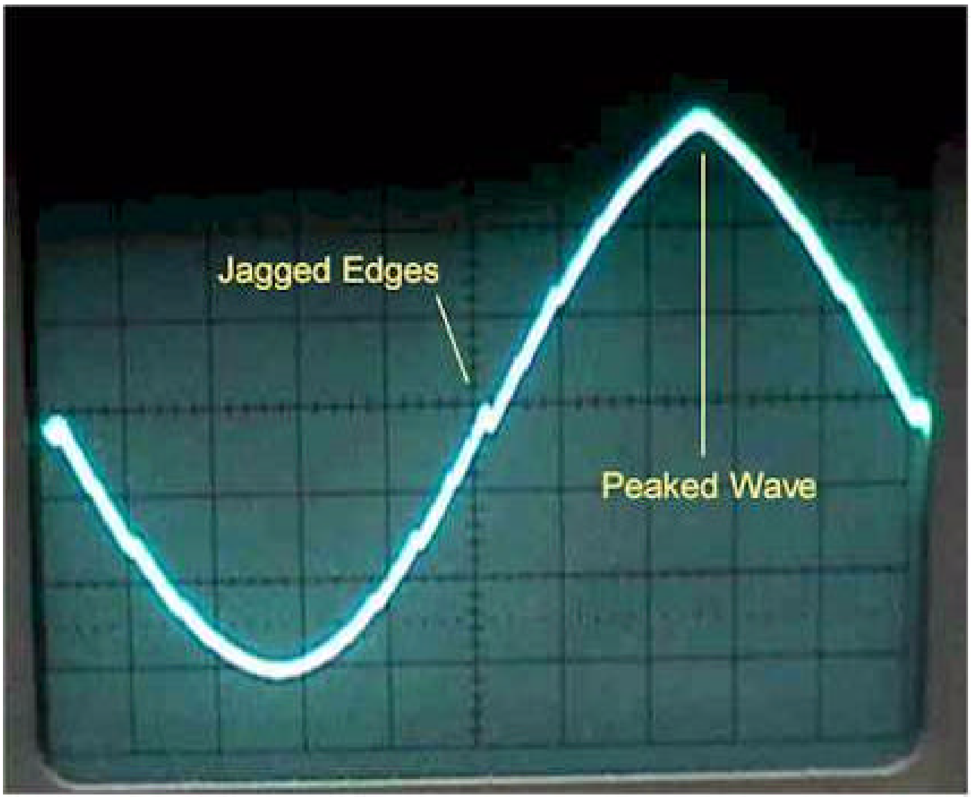


Figure 1. F-scan “sine wave” output @ 10Khz.

The second noticeable problem was that the amplitude of the wave fell off with frequency, well within the quoted operating range of the device (3Mhz). The device was unable to maintain the specified 10V and 1V amplitude ratings across its entire frequency range. The electronic bandwidth was under 2 Mhz - less than 2/3 of the stated range of the device.

Figure 2 shows the measured amplitude of the “sine wave” output at various frequencies. Note that these figures include the noise contribution as well which is considerable - the true amplitude of the actual pure frequency is lower than this.

Frequency (Hz)	Amplitude (V)
100	10
1,000	10
10,000	10
100,000	10
200,000	9.8
400,000	9.6
500,000	9.4
600,000	9.2
800,000	8.8
900,000	8.6
1,000,000	8.4
1,500,000	7.4
2,000,000	6.6
2,999,999	5.4

Figure 2. Amplitude variation of "sine wave" output with frequency

The rectangular wave option of OUT1 creates a TTL level signal. The specifications of the signal were consistent with TTL however the frequency stability was extremely bad and the signal was subject to significant jitter, preventing any accurate frequency from being produced by it.

The output from OUT2 was similarly examined. The waveform of this output is described as "rectangular" - it was not even remotely rectangular. The wave has an extremely low proportional rise and fall time and was therefore trapezoidal in form. The wave from this output is clearly nothing more than a clipped sine wave. The rise time was estimated at around 11% of the signal period.

Figure 3 shows an oscilloscope trace of the F-scan "rectangular wave" output.

The manual of the F-scan gives graphic drawings of the waveform outputs and shows true sine and rectangular waveforms. These drawings are misleading. The "sine wave" produced by the machine is not a sine wave and the "rectangular wave" is not rectangular. On the output panel of the machine there are further drawings of the waveforms, the sine is again misleading but the trapezoidal wave is correctly shown.

The device claims to be stable to within 100 parts per million, which means that it should produce a stable output that does not vary by more than the set frequency multiplied by $1 * 10^{-4}$.

Taking the top end frequency of the machine as an example, which is 2,999,999.99Hz, the variation should be within 299.99 Hz. When measured with a calibrated frequency counter the frequency (OUT1) was found to vary in practice by an amount in excess of 500Hz, well outside the 100ppm specification.

The TTL option of output 1 was also found to be extremely unstable and subject to jitter well in excess of 100ppm.

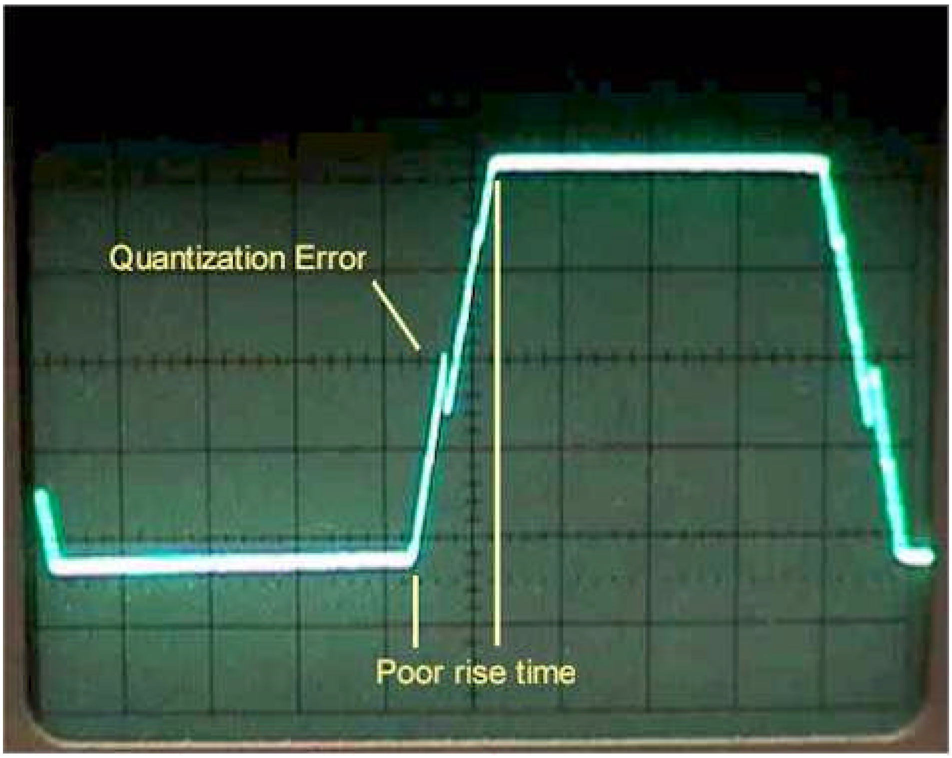


Figure 3. F-scan "rectangular wave" output @ 377Hz

2. The "Scanning" Function or "DIRP"

Most users will specifically buy the F-scan for this particular function which is unique to this machine.

The manufacturer appears for the most part to have carefully avoided making the specific claim that this function determines "pathogen resonances", however it is widely advertised by some distributors and resellers and accepted amongst the general public that this is what it does, and the manufacturer's presence and presentations at public events continue to encourage and foster this idea. It is impossible for the manufacturer not to be aware that his presentations are interpreted generally as such a claim, and if it is not the manufacturer's intention to make such a claim then to keep silent about it is a form of misrepresentation.

Furthermore on page 11 of the standard F-scan manual[1] (SW version FSRA32410) there is a section entitled "Which function should be used for a start?". Under this heading the manual says the following (second entry):

> *"There is a reason to believe that pathogens not yet identified by other diagnostic methods take part in causing disease symptoms. An attempt should be made to find and treat. Go to the chapter DIRP - for the upper frequency band."*

This clearly links the "DIRP" function with the idea of finding and treating pathogens. Which is tantamount to a claim to that effect.

What is “DIRP”?

The manufacturer is vague about what DIRP is actually supposed to be. It claims to be an acronym for “Dual Integration Resonance Procedure”, however this procedure is not described anywhere in sufficient detail to make a technical evaluation from the presentation alone.

In the F-scan manual, page 22 it claims that “DIRP” is a newly invented automated procedure to get a resonance feedback from a patient if a frequency is fed to him. It goes on to associate the alleged “resonance feedback” frequencies with frequencies assigned to pathogens by Dr Hulda Clark. Which reinforces the idea that these “resonance feedback” frequencies are equivalent to “pathogen resonances”.

I have extensively analysed the F-scan and what it is doing during this “DIRP” scan. I can state definitively that it does not detect “pathogen resonances” (or any other form of “resonance”) in any shape or form (assuming that pathogen resonances exist). Furthermore there is no evidence that the machine detects anything at all related to the body of a patient, and I believe therefore that it only measures electrical noise which it generates itself due to poor circuit design. I will describe this function and something of the hardware of the F-scan in detail in order to prove this point.

Description of the DIRP Process

I will cover this in two separate stages. Firstly what the user perceives and the specifics of setting up the DIRP scan, and secondly the actual technical basis of the process.

In addition to the two frequency outputs on the top of the machine there are a number of further small connectors on the side. The bottom connector of the machine is labelled “Sensor”.

This sensor jack connects to a simple two wire connection, and the wires lead to two electrical contacts which are attached to a velcroed cloth band.

In order to perform the DIRP scan the user is asked to attach a special cable to the frequency output OUT1 of the machine - this is the one with the “sine wave” output. The other end of this cable attaches to a single hand held metal electrode which is basically a section of copper pipe - the deluxe model being gold plated. The user is asked to hold this metal electrode in the left hand.

None of the wires or connectors are in any way electrically shielded.

Figure 4 shows a picture of the hand held contact (the gold plated version) and the finger sensors on the velco band.

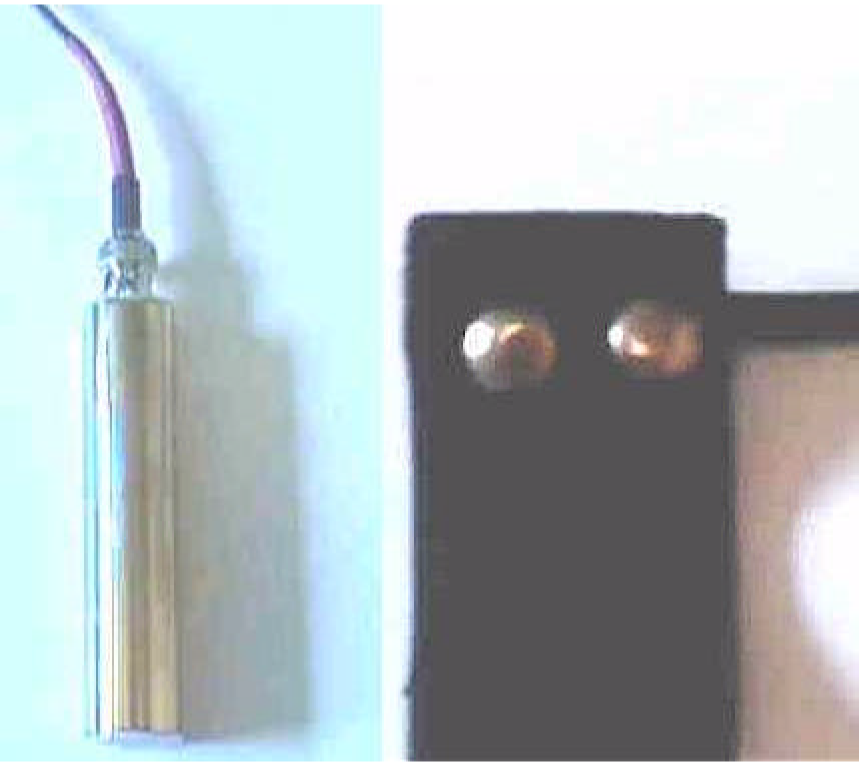


Figure 4. F-scan hand held electrode (left) and finger sensor (right)

The sensor described above is wrapped around the top of the middle finger of the right hand in such a way that the two electrical contacts inside the band are in contact with the skin of the finger. This is shown in Figure 5.

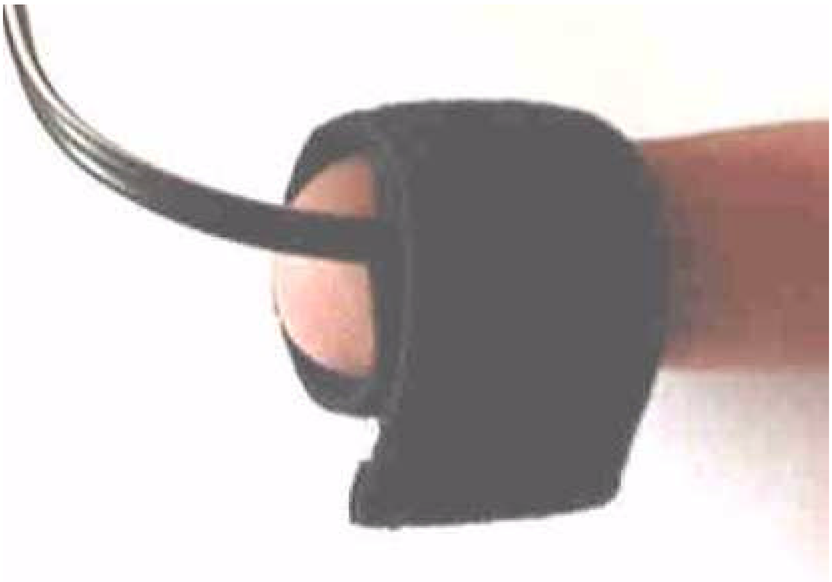


Figure 5. Positioning of finger sensor

In standalone operation, the user then enters two frequencies into the machine, a lower and an upper frequency of a range of their choice. A separate button marked "DIRP" is then pressed to prime the process and the process is actually started when the user presses a separate "start" button.

Provided the contacts are attached correctly, the machine begins scanning between a range of frequencies (usually a subset of the chosen range) in order to allegedly determine body conductivity. At the end of this process it determines two values, one called "CV" or conductivity value which is expressed as a percentage, and another called "CL" which is a threshold level - the machine will beep and record any responses on the sensor which exceed the CL level. After this determination and the calibration run, the machine then proceeds to perform the proper DIRP scan. It steps through a number of frequencies between the ranges specified and records the response as an integer value. If the response exceeds the set CL level, the machine sounds a warning beep and records the associated frequency in its internal memory.

At the end of the process the user is encouraged to refer to various lists of alleged "pathogen frequencies" to determine what pathogens they allegedly have. The machine then also gives the option of applying the chosen frequencies via a choice of electrodes (the copper pipe hand helds by default) to the body of the user.

The manual of the machine directly claims to eliminate specific pathogens from the body by applying these frequencies via the machine.

A similar process may be operated remotely from a computer attached to the F-scan via a special serial cable (optional extra) and associated software. The remote software allows the user more control of the scanning process, including the option of setting the frequency step during the scan, which appears not to be possible (or is at least undocumented) with the standalone machine. With the computer software it is possible to store the entire response set from the frequency scan on to the computer's disk and also to see a graph of the alleged response. It is also possible to capture the data from the serial connection to the computer with the serial connection alone and simple terminal software, so the software is not essential.

What is really happening?

The DIRP scan sounds very mysterious and technical. There is a lot of unfounded speculation amongst users of the machine as to what it does and certain resellers actively encourage misinformation about the nature of the process. I will now give a detailed technical description of what the machine is actually doing, and why I consider the results of this operation to be completely meaningless.

Firstly the hand held connector is connected to the "sine wave" output of the machine. During the DIRP scan the machine actively outputs a number of successive frequencies to this electrode. The waveforms output during this process are identical to the normal waveforms during ordinary frequency generation, and in particular, the extreme harmonic distortion of the machine is unchanged, so the output does not consist of a single pure frequency sine wave but rather a badly distorted sinusoid with a lot of extreme high frequency harmonics and electrical noise.

The sensor connection appears to consist of two electrodes. In fact, one of the electrodes is just a ground connection (the left hand one in the right side picture of Figure 4) - so this electrode provides a common ground for the “sine wave” output above and the sensor. The other electrode of the sensor is the sensor itself. This is a pure single ended electrical connection (not differential) and has no electrical shielding against electrical noise and interference.

So the circuit of the F-scan as it relates to the user during a scan is a simple two electrode system (one in, one out), despite the presence of 3 physical contacts. And in fact the system will “work” even if the ground contact is not connected as the grounds are already connected internally. This can be easily confirmed by running a “DIRP” scan whilst just pressing one finger against the lower of the two finger contacts and holding the hand held against the skin.

So in this process, the user or patient is simply connected between two electrodes and a current is passed through (or across the surface of the skin of the patient) between the electrodes.

In actual use it is quickly evident that the system is subject to a number of common errors well known to be associated with this kind of measurement. In particular two main factors were clearly identified. One was that the device is highly sensitive to skin resistance of the subject and in a related manner, the integrity of the contact between the electrodes and the skin of the subject. The second was that a significant proportion of the electrical current between the electrodes appears to flow through the blood of the subject, thus making the device extremely sensitive to changes in blood pressure and even posture of the subject.

During the course of a scan, a slight relaxation of the grip on the hand held electrode will result in a sudden peak in the reading which is then interpreted as a “resonance”. Similarly a postural change resulting in a sudden change of blood pressure will cause the same effect (such as raising the legs whilst lying down). Other changes such as sweating, startling the subject etc., will cause similar sudden peaks in the measured response.

It was further observed empirically that strong electrical noise in the vicinity of the subject would also cause peaks in the readings.

There is a further problem which is ground loop noise. Since one of the sensor contacts is a ground and the grounds between input and output are already connected internally, the system may pick up “ground loop” noise, which will further be falsely interpreted as a real reading.

A number of users have reported that the device seems to constantly detect what appears to be harmonics of a particular low frequency. After conducting numerous scans I was able to confirm that the device mostly appears to detect constant patterns which seem to be multiples of a base frequency in the region of 1360-1370 Hz (see footnotes) with regular sub harmonics on either side of them. The machine further detects a weaker sub multiple of exactly half this amount.

Although this phenomenon superficially appears to be some sort of harmonic resonance, it is not - the major peaks continue right across the frequency spectrum of the machine with little variation in amplitude. Harmonics would tend to drop off in amplitude further up the spectrum. This clearly indicates that the phenomenon is not resonance nor harmonics but rather aliasing noise.

This latter assumption is confirmed by an examination of the F-scan circuitry. In order to properly explain what the F-scan is really measuring, I will need to discuss the internal circuitry and design of the device in some detail.

Inside the F-scan

The F-scan consists of a simple Z80 based CPU (central processing unit) with integrated peripherals. The machine uses an external EPROM and RAM chip. The frequency generation part is provided by means of a standard Harris DDS (Direct Digital Synthesis) chip which is clocked at 32 MHz. The output of the Harris chip is then fed directly to a simple R2R resistor ladder network (this will be expanded upon below) which in turn is fed directly to a very simple operational amplifier buffering and level shifting stage without any form of anti-alias or harmonic filtering. This goes directly to the output connectors.

The sensor part of the circuit is extremely simple. It consists of a single chip with an analog input and single bit digital output. The output is fed directly into a single bit digital input to one of the CPU peripherals (the PIO). The DDS chip and the sensor chip have had their markings deliberately removed to confuse identification. The DDS chip is obvious but the exact sensor chip isn't. More on that later.

The entire circuit design is extremely poor - there are a number of severe design errors that explain the many anomalies of the device. Furthermore the total internal cost of the circuitry is only a tiny fraction of the retail price of the device. The build quality of the device I examined was poor as well.

I will now examine some of the design errors in detail as a preliminary to explaining what the device is measuring as these errors are responsible for the alleged results produced by the machine.

Design Flaws

Above I mentioned that the DDS output is fed to a resistor R2R ladder. This is not strictly true because the resistor ladder used in the F-scan is NOT a true R2R ladder. An R2R ladder is a simple network of resistors that is commonly used for digital to analog conversion. It should consist of extremely well matched pairs of resistors in the ratio of exactly 2:1 - i.e. a precise 1KOhm resistor should be exactly matched to a precise 2KOhm resistor. In the F-scan, the manufacturer has used ordinary unmatched resistor SIL arrays which typically have tolerance variations of up to 10% between individual elements. This was confirmed by direct measurement. So the arrays are not precisely matched in the correct 2:1 ratio due to resistor tolerance variations.

However, in addition to this, the designer has also used a common E6 series "preferred value" of resistance instead of a matched resistor array. So the actual array consists of a set of 2.2KOhm resistors (+/- 10% tolerance) combined with a set of 1KOhm resistors (also +/- 10%

tolerance), confirmed by both measurement and the markings on the devices. Even if the resistor arrays were ideal (0% tolerance) they would have a best case ratio match of 2.2:1 and so could never possibly achieve the correct ratio in practice except by the extreme and very unlikely coincidence that the tolerance variations of both sets of resistors just happened to settle out at an exact 2:1 ratio for every individual resistor in the array. But for the same reason, and with equal probability, this ratio can change in practice in different machines to as much as 2420:900 which is a real ratio of 2.69:1.

This is a drastic and catastrophic design error! The only way that the conversion process will proceed correctly is if the actual ratio is precisely fixed and stabilised at exactly 2:1 (because the R2R process relies on the binary addition of powers of 2, NOT powers of 2.2 for example). In the case of the F-scan, the non-linearity of the conversion ladder results in massive harmonic distortion. In fact it is clearly this that is responsible for the “jagged edges” of the “sine wave” output. This distortion, (known technically as quantization error) appears as discontinuities at the changeover of each set of binary bits output from the DDS chip, and appears in practice as spikes or jags in the waveform. The fact that this is the case is easily confirmed by way of a simple mathematical and graphical simulation which accurately predicts the appearance of the F-scan output wave.

Figure 6 shows the result of a mathematical simulation of the properties of an R2.2R ladder compared to a true R2R ladder. Note how this is very similar to the actual photograph of the waveform output of the F-scan in figure 1.

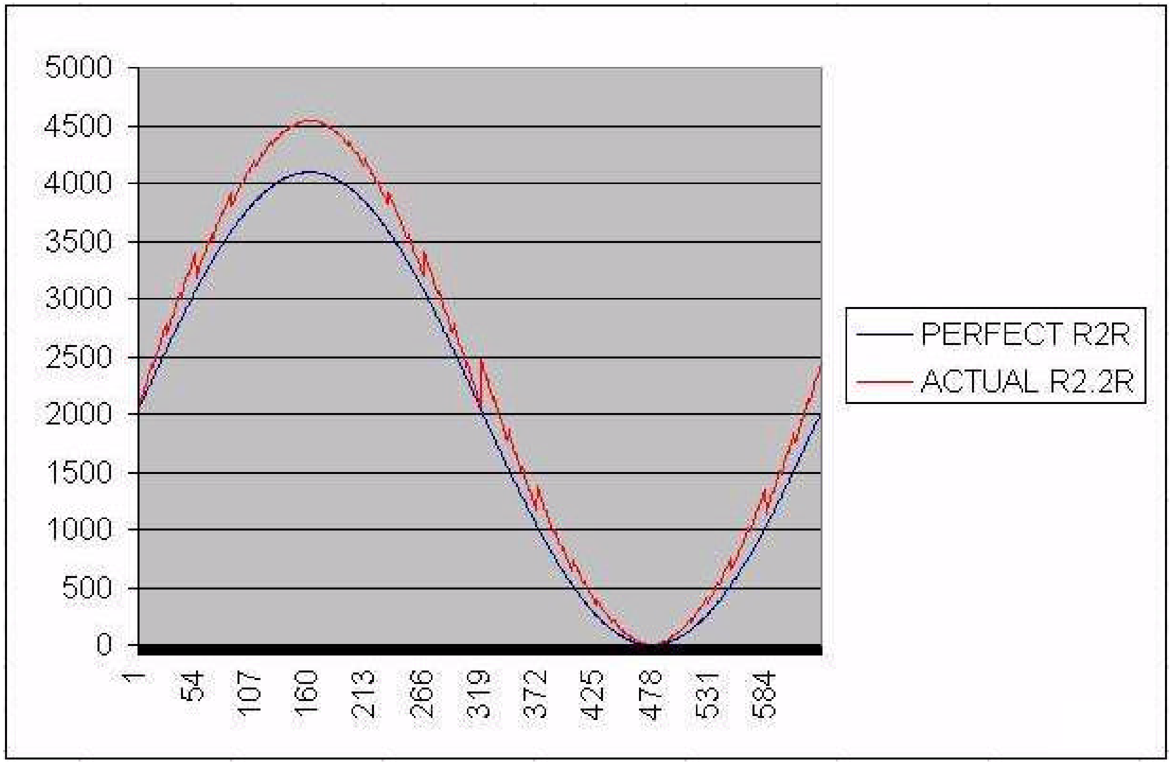


Figure 6. Mathematical simulation of the effect of mismatched DAC ladder

The simulation shows a perfect 2.2:1 match. However, given the tolerance variances in the real devices inside the F-scan, the real distortion may actually be much worse than this in specific machines.

In any design of this sort it is unusual to rely on a discrete R2R ladder for such conversion in any event - particularly if waveform integrity and frequency accuracy is desired. A professional designer would typically use a dedicated digital to analog converter chip with internal laser trimmed precision networks. The only legitimate use of such an arrangement as is employed in the F-scan would be in the event of trying to cut back cost to a bare minimum (a total saving of maybe $15 in practice) or where frequency accuracy is not at all important. Given the retail price of the F-scan (in the region of $4000) and the claimed specification as a high accuracy frequency generator and measuring instrument, such measures cannot possibly be justified.

As the circuit in the F-scan cannot be reasonably described as an R2R ladder I will call it a “DAC ladder” from now on.

The output of the DAC ladder is fed directly to the non-inverting input of a high impedance operational amplifier. Because the op amp presents an extremely high impedance to the low output impedance of the DAC ladder, there is very little current loading on the DAC ladder. In electrical terms the DAC ladder does not present a “stiff” output and is therefore prone to electrical noise and non-linearities due to impedance mismatch. This results in the peak in the top of the “sine wave” produced by OUT1 of the F-scan. This is another serious design flaw.

In order to prove that this was the case I tried attaching a resistor to ground from the output of the F-scan DAC ladder and this resulted in a major improvement in the waveform (but not the quantization errors) and the disappearance of the “peak” in the “sine wave”.

The above situation is serious, but I was then further absolutely amazed to discover that the F-scan has no anti-alias filter at all on the DDS output! During the DDS conversion process, a phase accumulator inside the DDS chip is recursively added to itself plus an offset value held in a settable register once every clock cycle of the master clock. This results in a series of binary values that represent phase samples of a periodic wave. These phase samples are fed to a sine or cosine lookup table internal to the DDS chip to determine the correct amplitude setting for each phase value. The output then consists of a successive series of digital samples of values of a sine or cosine wave.

Because the data of the wave (the sine or cosine lookup table) consists of sampled values the output will only be valid for frequencies up to the Nyquist limit of the sampling rate - i.e. one half of the sampling rate. Due to both phase and amplitude quantization error which is natural in sampled systems the output spectrum will consist not only of the desired frequency but also of aliases of the frequency. These aliases will be mirror images of the output frequency “folded” about the Nyquist limit. The net result of this process is that the direct output of any sampled system (and particularly a DDS chip like the one used in the F-scan) will consist not only of a pure and accurate frequency but a whole series of additional frequency components due to both aliasing and quantization error.

Although it is theoretically possible to achieve a frequency output up to the Nyquist limit, the proximity of the aliases to the fundamental near the Nyquist limit makes practical discrimination very difficult and so in practice, designers limit the output of a DDS device to typically 80% of the Nyquist limit - or some 40% of the master clock frequency (MCLK) of the DDS itself. They do this by feeding the output of the DAC stage into an anti-aliasing low pass filter with a sharp cut off around the 40% MCLK point to remove the unwanted amplitude quantization harmonics and aliases. The required order of the anti-alias filter will typically vary in practice depending on the accuracy desired by the designer. But in practice, in similar systems which I have designed in the past, I have found it desirable to use an Elliptic or Chebyshev filter of at least the 8th order, with a zero close to 40% of the Nyquist limit and at least 50dB minimum stopband attenuation to maintain the kind of accuracy range that the F-scan claims to have.

But the F-scan has ***no*** filtering at all on its DDS DAC output! This means that the real output consists of a whole series of multiple frequencies, quantization harmonics and aliases, instead of a pure frequency. In practice, the only limit to the amount of this harmonic noise appears to be the bandwidth of the output operational amplifiers.

This latter point raises a 4th major design flaw. The output op amps have gain/bandwidth products well below what is necessary for constant output of the signal across the entire operating range. It is the latter that causes the fall off in output of the F-scan at higher frequencies and which is responsible for the low bandwidth of the device.

The above factors alone represent 4 extreme design flaws in the F-scan and account for the poor quality of the alleged “sine wave” output. The trapezoidal wave that is produced by OUT2 of the F-scan is derived from the “sine wave” by way of overdriving and clipping (using another low bandwidth op amp) as I predicted above. But the quantization errors present in the “sine” output are carried over and amplified in the trapezoidal output, as is evident in Figure 2 above. So this output also suffers from extreme harmonic distortion.

Finally as if all the above is not enough, there is a further major error. The rectangular “TTL” wave option on OUT1 is derived by connecting a Schmitt Trigger TTL chip directly to the most significant output bit of the 12 bit digital output of the DDS chip.

The digital output lines of the DDS chip represent powers of 2 in the digital representation of the amplitude of the sampled sine wave. So the most significant bit of the digital output lines is a very approximate representation of the positive and negative half cycles of the sine wave output. This may seem to be a simple and efficient way to derive a square wave from a sine - however there is a major problem with this technique. The actual cross over point between positive and negative in the sampled output is not represented solely by the most significant digital bit. In many cases, the true cross over point is not output directly but is interpolated by means of the smoothing of the anti-alias filter. Since the F-scan HAS no anti-alias filter it is impossible to derive a true square wave from the “sine” output alone.

The result is that the changeover from binary 0 to 1 of the most significant digital bit of the DDS does not necessarily lie exactly on the true zero crossing point of the sine wave interpolated output. And the consequence of this is that the output of this bit shifts significantly in phase (one output sample period) on each successive cycle in which the total number of output samples per cycle is an odd number. This results in extreme frequency “jitter” which adds significantly to the noise generated by the system, and renders the TTL output completely inaccurate in frequency. This jitter gets worse in proportion the higher the output frequency gets. And in addition the variation in the duty cycle of the rectangular wave due to this jitter of the transition point adds further unwanted even harmonics to the output.

The above 5 design flaws explain exactly the extremely poor observed performance of the F-scan frequency generation function and outputs. This design is of nowhere near professional quality and is even inferior to many amateur designs freely available on the internet.

The Sensor Circuit

As explained above, the exact chip type of the sensor chip is unknown. It is possible that it is some sort of simple operational amplifier, a comparator or a sample and hold amplifier, an instrumentation amplifier or a serial analog to digital converter. The pinouts correspond most closely to an instrumentation amp or serial ADC and the code which senses the output in the processor appears to correspond to a 12 bit serial ADC reading. Of all the options the serial ADC would be the most appropriate and the most “capable” of all the options so I will assume that this is what it is. If the sensor is NOT a true ADC then it is much more limited and incapable of even doing what I will ascribe to the ADC circuit, so this assumption does not add any unfavourable bias to the review - quite the opposite in fact.

A 12 bit ADC device would be capable of measuring 4096 discrete voltage levels at its input. This would in general terms be a high precision device assuming the presence of a proper internal reference, some sort of sample and hold facility and a high sample rate.

Without knowing what the actual chip is, it is impossible to say what its sampling rate is. However in general, most commercial monolithic 12 bit serial ADC’s have limited low speed sampling rates. It doesn’t matter however, whether or not the device does have a fast sampling rate because the output is entirely dependent on the rate at which the processor can read the data from the chip in any event. And because it is a serial device, the readout is a slow process (relatively speaking).

In the F-scan, the output of the sensor chip is connected directly to an I/O line of a Z80 PIO (integrated with the CPU). Such I/O lines are capable of inputting a bit midway through a T4 cycle (the minimum I/O cycle requires 4 processor T states, including one mandatory wait state). The actual sub section of code which reads 12 successive bits from the sensor chip requires 176 or 177 processor T states (depending on whether a particular branch is executed), and this does not take into account the surrounding code which sets up the chip and stores the result, nor the calling routine. The CPU of the F-scan is a Z84C1516FSC processor which can run at a maximum clock rate of 16Mhz.

The sensor input subroutine is at address 2F16H in the F-scan EPROM (V4.10). This routine is loaded into RAM and actually executed at address 9F16H during machine operation. The overall subroutine requires a total of 554 (or 555) T states, with 176 or 177 of those occupied by the inner read loop.

With a processor running at 16Mhz, one T state is equal to 1 cycle of a 16Mhz clock, i.e. 62.5nS. So 554 T states requires a total time of 34.625uS which corresponds to a maximum sample read rate of 28881 samples per second.

In practice of course, even this is not achievable because the calling process and result processing will take many additional T states and further lower the real sample rate.

Now taking into account the Shannon and Nyquist criteria for data sampling, this means that the F-scan would only, under the most ideal conditions, be capable of sampling frequencies of under 14Khz and then it could only do so in a meaningful way if the sensor input was sharply filtered for any signals above this range.

This latter point requires further explanation.

Aliasing

At first sight it may appear that a high sample rate is not necessary if all that was required was some measurement of peak voltage. However, it must be remembered that as the F-scan is attempting to measure an AC signal, the magnitude of the voltage will depend on the exact phase of the sampling point. A wave measured at its zero point would read zero, and at its highest point would give maximum amplitude. If the exact frequency of the wave was known then a few samples even at a rate much lower than the frequency of the wave would allow reconstruction of the wave - however this would have to be based on one fundamental assumption - which is that the wave is pure and that there is no contribution to the overall wave shape from unwanted or spurious harmonics, aliases or noise.

In the case of the F-scan, this assumption does not hold true. Firstly the measurement is made across human skin and the body as a whole is a very efficient pickup of electrical noise - much of which manifests as a voltage across the skin. In addition, as explained earlier, the output of the F-scan is anything but pure - it contains major quantization noise and aliasing noise. And of course the pickup for the sensor is not shielded in any way. Finally there will even be a contribution to the overall noise from simple Boltzmann noise generated by ions within the body.

So in effect, the F-scan is measuring a massive amount of electrical noise, which although much of it is harmonically related to the frequency being measured, is nonetheless indistinguishable from the true wave in the absence of a filter. Once again this is aliasing. A high frequency distortion may appear to be a wave of much lower frequency than it really is, and so the distortion will masquerade as the signal the machine is trying to detect.

The only way that it would be reasonably possible to avoid measuring this noise (apart from adding a hardware, variable, narrow band bandpass filter at the sensor input) would be to sample at a sufficient rate to properly resolve all the noise and then by means of digital filtering on the high rate samples (with optional decimation), effectively remove the noise and extract the original signal. As an alternative, the high rate sampled data can be Fourier transformed and the spectral component of the desired frequency can be isolated and measured. But either method requires sampling at a rate which will properly resolve the noise. One major component of the noise as a result of quantization and bleed through from the circuit is the 32Mhz master DDS clock. And so the absolute minimum required sampling rate according to the Shannon/Nyquist criteria would need to be of 64Msps (64 million samples per second) to extract the correct data from the noise. And this only takes into account the noise generated by the F-scan itself - higher frequency noise from other sources may require additional filtering and/or an even higher sampling rate.

As has already been mentioned above, the maximum sample rate of the F-scan cannot exceed approximately 28000 samples per second, which is nowhere near the required minimum of 64,000,0000 samples per second. The conclusion is that the F-scan is inherently incapable of distinguishing its own noise content from the true signal without additional hardware filtering - which it does not have. And in these circumstances the F-scan must suffer from aliasing effects which will generate false readings due to its own noise and aliasing - which confirms the observations and tests exactly.

Testing for "Resonance"

In order to determine if the F-scan was giving any form of meaningful output I decided to set up a very simple test rig.

In the first experiment I took a high quality 1MOhm resistor and set it up on a test rig using professional equipment to determine if it had any significant variation in its frequency response in the range from approximately 100Hz up to 100Khz. I determined that there was no such response variation and that the resistor was flat and constant over this range.

I then connected it between the OUT1 connection and the sensor input, and ran various scans on it. Firstly, each scan registered peaks and a widely varying response. Since I had already determined that the resistor had no variant frequency response in the ranges in question it was clear that the result was a false reading.

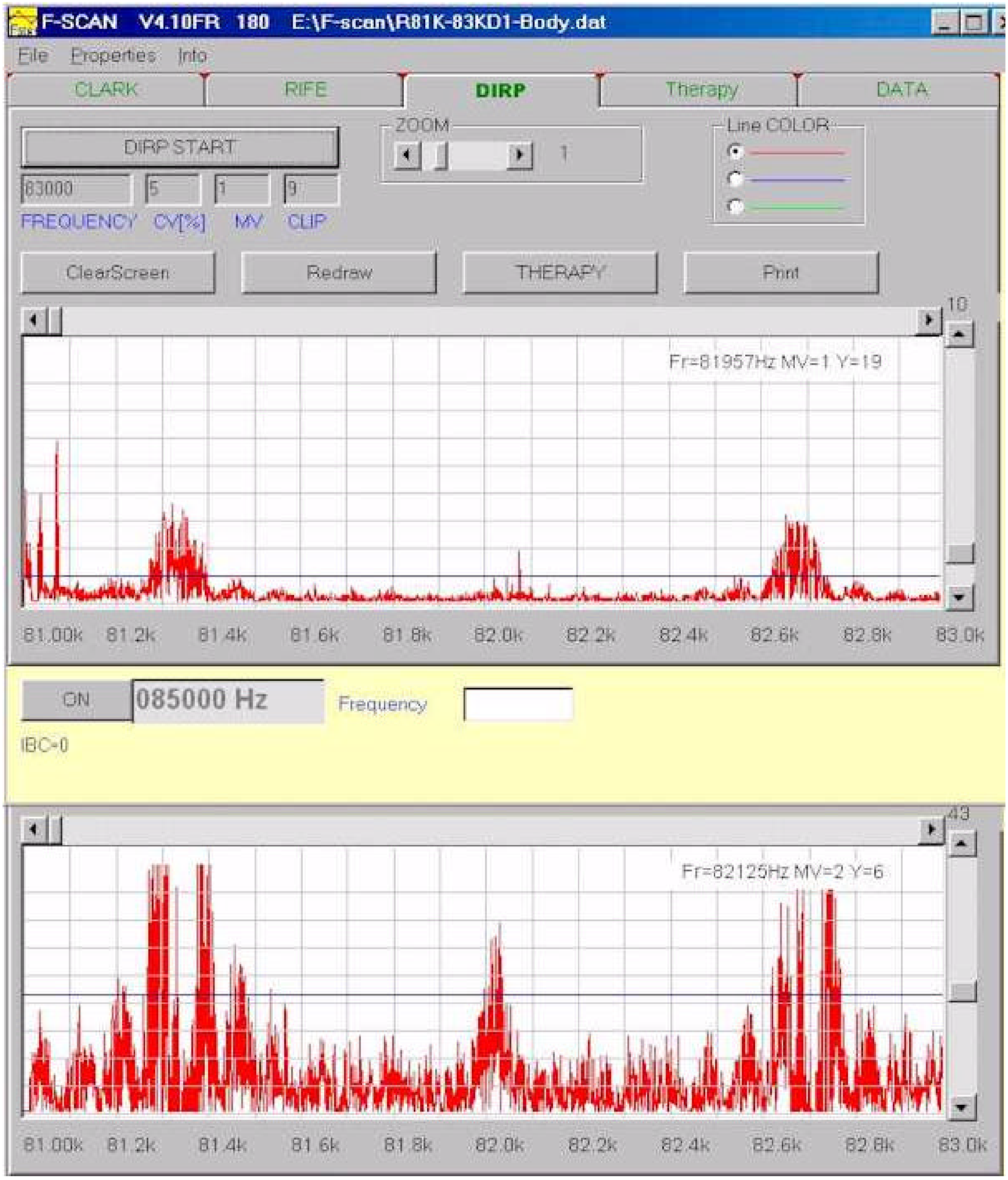
Secondly, successive scans of the same resistor across the same range showed significant variations in the measured "response" - indicating again that the response was just an artifact.

Finally, examination of the responses of the resistor showed that the peaks in the response corresponded exactly to the commonly observed "1360 Hz" series (see footnote) that many F-scan users have reported. Further, smaller peaks were detected at half way points between the 1360 points.

Upon examination of several scans it was evident that I was looking at aliasing noise - this kind of noise tends to have characteristic patterns and the F-scan was giving those kind of patterns. The changes in the response from scan to scan were also a clear indication of shifts in the aliasing pattern due to the shifting phase of the noise relative to the input signal.

Further tests were conducted on a potential divider network which also had an independently measured flat response. The same patterns were evident in these tests.

Finally I ran tests on myself in the same ranges and noted that with the exception of larger peaks and more noise in the readings, there was a close correspondence in the patterns of my alleged body response and that of both passive networks (see Figure 7 following for an example). In all cases, peaks of varying magnitude were obtained in a clear pattern of approximately 1365 Hz intervals in the entire range up to 100Khz.



F-SCAN V4.10FR 180 E:\F-scan\R81K-83KD1-Body.dat

FREQUENCY 83000 CV[%] 5 MV 1 CLIP 9

ZOOM 1

Fr=81957Hz MV=1 Y=19

ON 085000 Hz

IBC=0

Fr=82125Hz MV=2 Y=6

Figure 7. Comparison of F-scan output for body (top) and resistor network (lower) for a range of 81KHz to 83Khz in 1Hz steps.

Some common peaks were observed at certain points in the higher range in all samples (including the resistors), for example around 65,000 Hz and 81,000 Hz. In all cases the peaks obtained corresponded exactly with the running "1360" series. As can be seen from Figure n, the F-scan always detects a major alias of the 1360 series around 81300 Hz - which when performed as a 1000Hz step scan is usually attributed (by the machine) to 81000 Hz and is claimed by some resellers of the machine as "proof" of its effectiveness on the grounds that 81000 Hz represents "Argyria" (silver poisoning) and because it is often found in people who take colloidal silver! This 81000 Hz peak varies in amplitude depending on the phase of the ambient noise at the instant of measurement. So in a crude scan sometimes it will be apparently present and other times not.

In some cases spurious transient peaks were noted, but these did not appear on successive scans and in some cases were easily correlated to electrical noise events (i.e. machinery switching) in the vicinity during the measurement run, as well as postural changes etc.

There was no evidence whatsoever that would suggest any meaningful response pattern other than pure electrical noise, aliasing noise and in the case of the body measurements, skin and blood resistance changes due to postural changes.

I came to the conclusion that most of the measured F-scan response was aliased samples of electrical noise generated by the F-scan itself. In order to test this hypothesis I conducted another set of 3 runs on the potential divider network and noted that I got the usual responses. I then connected a sharp bandpass filter between the output of the F-scan and its output lead. I verified that the quantization noise, jitter and harmonic distortion was not apparently present after the filter and that I was getting a good, clean sine wave from the filter output (across the scan range in question) that was approximately 10V p-p across the same range.

I then re-ran the same scan on the same resistor network and obtained an almost absolutely flat response with no peaks. The only tiny variation was one unit in one or two places - compared with an average pre-filter response of some 50 odd units. This demonstrated conclusively that removing the F-scan’s own noise from its output also removed its “capability” to detect “responses” in materials. This leads to the obvious conclusion that the F-scan only measures its own noise and nothing to do with the sample or subject being tested.

An examination of Figure 7 shows the above quite clearly. It contains snapshots of the actual output of the F-scan software for a real body (mine!) and a simple potential divider resistor network set for high amplitude response from the F-scan.

The major peaks at both ends of the graphs are approximately 1365 Hz apart. The central spike is exactly midway between these values. In the higher amplitude resistor sample the repetitive nature of the underlying noise, and the overall symmetry about the central spike is obvious, clearly showing aliasing.

The two spikes evident at the beginning of the body scan around 81 Khz are artifacts caused by sudden postural changes at that point in the scan, and illustrate how easily a misleading reading can be obtained with the machine.

3. Frequency Precision

The device claims to output frequencies adjustable to 0.01Hz. It also claims to allow storage and run of sets of pre-programmed frequencies. The advertising of the machine does not mention that the programmed frequency banks are incapable of storing decimal points or decimal places and that in the pre-programmed mode it is impossible to store a setting precise to 0.01Hz and that only a maximum precision of 1Hz is possible. Although the point is moot in the light of the fact that the instability, noise and harmonic distortion of the outputs, and even its rated specification of 100ppm stability makes the accuracy of the machine less than

1Hz for most of its operating range. However these points are misleading and would not be obvious to a casual, non-technical buyer.

4. Scanning Frequency Function

The F-scan offers a scanning frequency output function in which it is claimed a series of output frequencies in a range may be produced successively from botttom to top and then from top to bottom in a circular, continuous fashion. On page 19 of the F-scan manual however it mentions that if one required a scan between 100Hz and 3000Hz, it would be necessary to enter an upper limit of 4000Hz not 3000Hz in order to get 3000Hz! It says that this is due to the “mathematical algorithm” used by the machine. However, quite simply it means that you don’t get what you ask for - if the “mathematical algorithm” is deficient then how is an average user to know what upper frequency to set to obtain the desired scan range? So again, this is a serious flaw in that the user does not get what is reasonably expected and has no way of determining how to set the device in order to avoid this in general. The idea that one can just enter a frequency range and actually get those frequencies is misleading.

5. Minor points

There are other, lesser, misleading statements in the advertising and manual, I will not examine them all but will look at one example. The machine claims to use “the newly invented and very precise high speed oscillator system TNOC”. There is no explanation of what “TNOC” is supposed to stand for, I can only presume that it is some re-arrangement of the acronym “NCO” which stands for “Numerically Controlled Oscillator”, which is otherwise more commonly known as “DDS” or “Direct Digital Synthesis”. The machine does use a standard DDS chip to generate its frequencies. However this is hardly a “newly invented” technique! It has been around for at least 30 years, but has become more popular in the last 10 years or so with the advent of single chip implementations.

Conclusions

The specifications and manual of the machine are misleading. The device claims to produce a true sine wave and true rectangular wave. It produces neither.

Although it does not explicitly state that the machine gives a constant amplitude output across its entire operating range, it is implied by omission - a non technical user would never realise that the machine is incapable of generating the full 10V signal right up to 2,999,999.99Hz. More technical users would probably realise that some fall off at higher frequencies might be expected but would probably be surprised to discover that the bandwidth of the machine is less than 2/3 of its stated operating range.

In addition most ordinary users would not be aware that even if the machine ***did*** produce its specified 100ppm stability at constant amplitude across its operating range, that it still would not be guaranteed accurate to 0.01Hz for any frequency above 100Hz.

When it is generally advertised, there is no mention of the limitations of the outputs of the machine, particularly the bad harmonic distortion, or the bandwidth limitation or the fact that the "rectangular" wave is not rectangular. Furthermore there is no explicit mention in the general advertising that OUT2 has a very severely limited bandwidth and will not produce even a trapezoidal wave above 100Khz. In the manual mention is made that OUT2 is used for a "Rife Band" of 0-35Khz, and that OUT1 is used for a "Clark band" of 60Khz to 1Mhz. But these limitations would not be obvious to anyone buying the machine on the basis of its general advertising.

The poor rise time of the second output may be intentional and designed to prevent shock or burn when applied to the skin, although at the same time, such a shape is an inevitable consequence of using slow op amps with limited gain, so it is not clear whether it is a design feature or a design flaw. Many researchers in the field of Rife work believe that a fast rise time is essential for optimum effect and so may not be aware of this limitation - particularly when the manual shows something quite different.

In general the medical claims made for the machine are unproven. It is often claimed by resellers that the machine is "medically approved in Europe", however neither the manual nor the manufacturer's website mentions this claim. In the machine's manual it simply states that it is ***classified*** as a Medical Device Class 1, Type B, EN60601, Regulation 93/42EEC. Taken at face value this means nothing other than the fact that the device would fall into this category of classification and should conform to the electrical requirements of this regulation. The regulation in question relates to electrical safety of medical devices - in short it requires that the device will not kill you by electrocution, but it does not in any way imply that the device has been medically tested nor that it has been proven to actually work as advertised. It is not entirely clear from reading the regulation whether it requires any independent certification, or whether a manufacturer can simply self-certify the device as compliant. Ordinary users however are encouraged by some resellers to consider this item as proof that the machine has been "medically approved" - and that as such it is proof of its effectiveness as a diagnostic/therapy device and/or that it is recommended or endorsed by medical authorities within Europe. This in itself is seriously misleading.

The machine does not meet its 100ppm frequency stability specification.

The machine has a number of serious design flaws, namely:

a) Improper ratio in the DAC ladder from the DDS chip and use of cheap non precision parts.

b) Improper current loading on the DAC ladder.

c) Complete lack of anti-alias (or other) filtering on outputs or inputs.

d) Insufficient bandwidth of output amplifiers.

e) Derivation of rectangular signal from "jittery" digital output.

f) No shielding of sensor input connections or wires.

g) Insufficient sampling speed to correctly resolve signal from noise.

The build quality of the machine tested was poor, and the constructional techniques evidenced poor electrical practice such as long internal wires carrying high frequency signals across most of the internal circuitry of the machine, no shielding of the case or circuits etc.

The scanning function is meaningless. The machine allegedly reports “resonances” of the body and/or “pathogens” which are in fact artifacts of its own and other ambient electrical noise. But the purported association of these outputs with disease states is dangerous. Users may be misled into believing that they have a serious disease that they do not, or conversely that they are free from some disease that they do have. On this basis it may encourage people to take unnecessary medical treatment they would not have otherwise have taken, or not to take urgent medical treatment which they should. In extreme cases, people of a weak or nervous disposition may be inclined to take life-threatening action, for example, the possibility of suicide in someone who believes that they have some fatal and terrible disease on the basis of the machine’s readings.

Prolonged usage of the DC offset signals will eventually result in tissue damage at the point of application due to electrolysis of the body tissue.

The price of the machine is outrageous given the true nature and quality of the machine. Far superior, high end, professional frequency generator units, that do not suffer from any of the design flaws of the machine can be easily obtained for less than 1/3 of the price of the F-scan.

In summary, the entire presentation of the machine is misleading in almost every major aspect.

Footnotes and References

** The 1360 series is so-called because it represents sets of peaks in the F-scan readings with a repeating interval of approximately 1360 Hz. The actual number varies within a range, typically 1360-1372 Hz, but is usually consistent for any one run. So the use of the term “1360 series” should not be taken as an indication that the interval is always exactly 1360 Hz.*

1. F-scan manual (SW version FSRA32410)