Fluke 9640A-LPNX application summary

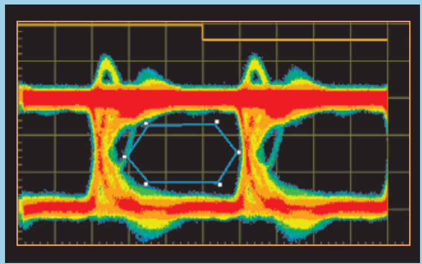
Particle acceleration

Hadrons are protons or ions that have been accelerated to great speed and energy. There are many particle accelerators around the globe designed variously to collide hadrons with hadrons from the opposing direction (for example, CERN) or with stationary materials.

Total energy in a hadron beam can be immense, equivalent to a speeding train; but the chance of a collision, or a collision in the right place, is minute. For this reason particles are "bunched" by passing through accelerating microwave cavities (velocity modulation at typically 400 MHz to 1.3 GHz). Even then, collisions are unlikely, and very few collisions are likely to be "interesting" or yielding of an alternate form of energy. The aim therefore must be to squeeze as many hadrons as possible (100 billion hadrons at CERN) into bunches (around 3,000) that are as small as possible (a few cm square by 16 um thick), travelling around thousands of times a second at the speed of light. This maximises the "luminosity" of collisions. Even so, in 200 billion speeding particles only 20 or so will collide, releasing energy equivalent to a hand-clap! That said, the physical space in which the energy is released is very tiny and concentrated, and bunches might collide at 30 million times a second to yield around 600 million collisions per second.

Time jitter in the microwave (velocity modulating) source will disperse the critical focus of the particles, greatly reducing the probability of collision and spreading the focus of collision energy. Not surprisingly therefore, low timing jitter becomes of tremendous value to these massively expensive and knowledge yielding experiments. The 9640A-LPNX has typically 20 % lower jitter than other available generators.

At KEK in Japan, the 3 km ERLINAC (Energy Recovery LINear Accelerator) is targeted to realize pulsed X-ray energy at 1.3 GHz repetitive rate and 100 fs~1 ps pulse width. From the 9640A, clean, stable pulse shape will require 10 mdeg of phase noise or around 20 fs jitter.



In particle acceleration and high energy research

Leading edge timing jitter/phase noise

- As the RF source to a synchrotron, particle accelerator or collider; leading edge timing jitter of the 9640A-LPNX gi ves focus to particle acceleration and bunching
- Ultimately results in higher impact probability and higher released energy
- Potentially a great opportunity for a Fluke source/Tektronix oscilloscope partnership. Each impact and released energy needs to be captured

Key specifications and features

Timing jitter: 32 fs rms, 1 GHz, 10 Hz to 10 MHz

Phase noise: -138 dBc/Hz, 1 GHz, 3 kHz to 100 kHz

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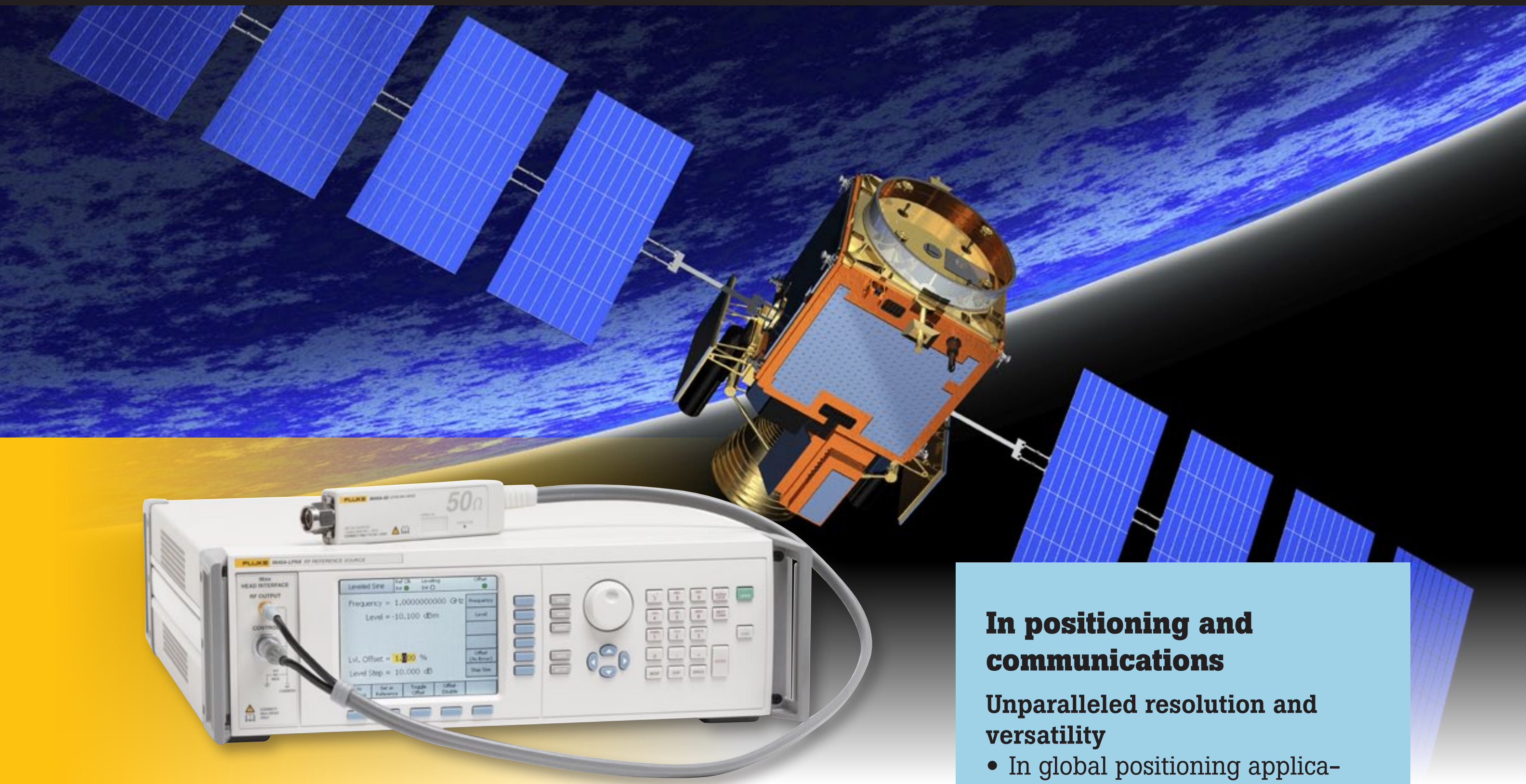

Positioning and communications

In global positioning, nanoseconds and nanoHertz translate into meters of positional error. Atmospheric mass and humidity, ionospheric, tropospheric, gravitational, relativistic, multipath, ephemeris (orbital position) and atomic clock errors all combine, after substantial correction, to give 15 m uncertainty to public systems. Military systems, able to decode advanced, often measured, correction data or make differential assessments can do a little better (0.3 m).

The current GPS system places at least 24 satellites in different orbits such that from all points on earth, 6 to 10 satellites can be seen at any one time. Each sends a time code (seconds into week number within year) on two carriers 1.57542 GHz (L1 signal) and 1.2276 GHz (L2 signal). GPS clock period is 10.23 MHz and relative arrival of a time code from each satellite is determined to around 1 ns by the receiver.

One example of correction is that GPS satellite clocks are offset from their terrestrial counterparts by 4570 uHz to 10.22999999543 MHz to overcome relativity. A clock traveling at orbital speed slows by 7 us per day. It also runs faster by 45 us per day because it is further out in our gravitational field than those on earth: a total of +38 us (roughly 10 km) per day to compensate. 9640A resolution of 10 uHz (unique in this class of instrument) can reproduce this offset to within ±5 uHz (or 10 m per day).

The same enhanced resolution applied to frequency sweep gives the 9640A unique ability to accurately sweep narrow frequency bands, such as a communications channel, adjacent channel, or a filter/resonator pass or stop band. When sweeping narrow bands (Span <0.03 % fc) the 9640A range locks its synthesiser to eliminate switching delays and realise smooth, linear, glitch free swept output. Oscillator pull and channel lock tests can also be performed.

When dealing with sensitive receiver inputs, the floating output and attenuation in the head give the 9640A good immunity to common mode and RFI noise injection at low levels.

In positioning and communications

Unparalleled resolution and versatility

- In global positioning applications, the 9640A-LPNX can perform precision offsetting of an atomic clock, for drift, Doppler, relativistic or gravitational frequency shift emulation
- For communications, filter, oscillator or resonator test, the 9640A features smooth, glitch and spur free and low residual channel sweep, for channel capture, oscillator pull, adjacent channel immunity or flatness testing
- In receiver test, floating output and precision attenuation at point of use ensures minimal noise injection

Key specifications and features

Frequency resolution:
10 uHz, 1 mHz to 4 GHz

Range locked sweep:
Span <0.03 % fc

Precision modulation:
AM, FM, ØM

General RF test and sourcing

The HP3335 & HP/Agilent 866x were extremely widely deployed RF sources and have typically been considered irreplaceable in demanding applications. The HP3335/6 were relatively low frequency (fcmax 80 MHz) sources, respected for their metrology grade and reliable attenuator, and configurable to 50 ohm or 75 ohm applications. They were uniquely capable in precise attenuation applications. Both have been obsolete now for nearly 10 years and the second hand market is running thin. The 9640A is an ideal replacement in applications that need the precision attenuator.

The HP866x sources, originally 500 MHz to 2 GHz, were known for their low phase noise. Unfortunately the 8662/3 were good for close-in (<100 kHz offset) phase noise, the 8664/5 were good at larger (>10 kHz) offsets. You had to select the source to application, occasionally having to use both (as in calibration applications). Agilent, while keeping and extending the 8663, have dropped the 8662/4 and 8665. The latter two leave a significant performance hole.

The 9640A-LPNX over-replaces all of these older instruments in a single unit, as closely as possible combining the phase noise performances** with the metrology grade attenuator, and adding precision levelling, harmonic filters, floating output and attenuation at the point of use. Fluke has delivered well proven GPIB emulation in both cases.

** Note that at 10 kHz to 100 kHz offsets, the still unique phase noise performance of the HP8664/5 is not quite matched; however, only rarely is this an issue.

A very common application of the 866x and similar generators is that of a high quality local oscillator within an RF system. Here the signal generator is frequency or phase locked to another source using an external discriminator in a voltage controlled feedback loop. Fluke has provided a polarity and gain configurable frequency pull input to facilitate this application. For instance, loop gain can be adjusted readily to track lock frequency changes without call for external circuitry.

Similarly, the 9640A supports external levelling via a highly configurable voltage levelling input. Thus, for instance, the output of a power amplifier can be levelled with a suitable power sensor.

In general test and sourcing

Over-replaces the obsolete and aging

- Leading edge accuracy, stability and resolution delivered with certified uncertainty, across all functions and entire dynamic range
- Very low distortion, spurs and residuals, ideal for digitizer (A/D) or amplifier testing: components through to cards and oscilloscopes

The 9640A is an instant plug-in replacement for many legacy high performance signal generators. Think of the 9640A as:

- The HP3335/6 with massively extended frequency range
- The "all in one" 8662/3/4/5 or 6020, plus metrology grade attenuator, plus floating, leveled, low noise output
- The ultimate local oscillator

FLUKE ®

Calibration

RF and microwave calibration

Unlike general purpose signal generators, when used manually or partnered with Fluke MET/CAL® software, the 9640A Series dramatically improves efficiency and capacity by reducing complexity, de-skilling, and speeding up calibration times. Automating calibrations using MET/CAL software to take control of the unit or device under test and all system instruments will increase system capacity by up to 25 % and will free up 50 % more of the system operator's time to perform other value-adding tasks.

The new 9640A-LPNX low phase noise model provides state-of-the-art low phase noise and jitter over an extended range of offset frequencies. An optional integrated frequency counter for reference frequency calibration and unique 10 uHz frequency setting resolution throughout an extended 1 mHz to 4 GHz range. The 9640A-LPNX and standard 9640A model add capability, further reducing system instrument count and support costs, and benefiting transportability for on-site calibrations.

The added functionality and improved phase noise performance are included with no price increases compared to the previous 9640A-LPN and 9640A-STD models. Existing 9640A series users may upgrade to latest 9640A-LPNX capability.

Fluke also introduced a new accessory: the 9600FLT 1 GHz Wide Offset Phase Noise Filter. In keeping with established use of filters to improve tight test margins at high offset frequencies for high performance spectrum analyzer calibration, this accessory is designed for easy connection and convenient mounting to 9640A models in either benchtop or rack mounted applications.

In RF and microwave calibration

Accuracy, purity and dynamic range

- The 9640A takes the central role and typically halves the cost of an RF calibration system
- In partnership, MET/CAL software calibrates spectrum analyzers, receivers, counters and level meters
- "Walk away" automation de-skills, reduces setups, increases system capacity (25 %) and labor efficiency (50 %)
- A 9640A-based system is robust, portable and environment tolerant, and enables onsite calibration
- The solution delivers certified carrier and modulation accuracy directly to the device under test, via a single connection

Key specifications

Frequency: 1 mHz to 4 GHz
Amplitude: -130 dBm to +24 dBm, 14 dBm @ 4 GHz (leveled)
Source match: <1.1:1 MHz to 500 MHz, <1.4:1 GHz to 4 GHz
Attenuation: ± 0.025 dB to -30 dB, ± 0.2 dB @ -110 dB
GPIB emulation: HP3335, HP8662/3

Fluke Calibration.
Precision, performance, confidence.™

- Electrical
- ▶ RF
- Temperature
- Pressure
- Flow
- Software

Fluke Calibration
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

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