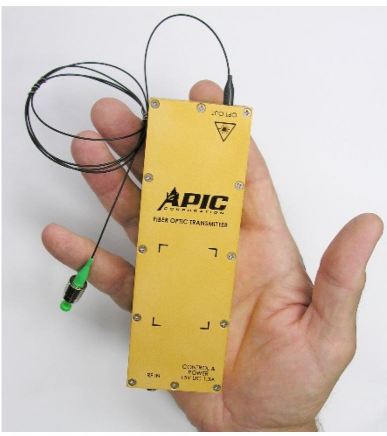
Dear Sir or Madam,

As a professional supporting our national security, we want to keep you informed on our cutting edge photonic integrated circuit technologies. The **Micro ATx** (20 GHz RFoF Transmitter) is APIC's latest high-performance military grade RF over fiber product. Whereas most COTS RFoF components are adequate for commercial antenna applications such as IF Satcom Band, GPS, VHF, UHF, PCS Cellular, Wi-Max, 4G LTE, etc., our products excel in achieving best-in-class <u>signal fidelity</u> and <u>ruggedness,</u> designed specifically for advanced weapon systems and military applications such as EHF SATCOM terminals, microwave communications, electronic warfare, signals intelligence, electronic surveillance, radar systems and antenna arrays.

Our Micro ATx combines an ultra low-RIN (-168 dB/Hz) continuous wavelength (CW) laser (1530-1565 nm), a low Vπ amplitude modulator, a low noise amplifier, power conditioning and control electronics into a very small, yet, very rugged package (14 x 5 x 2 cm). When used in combination with APIC's highly linear 20 GHz analog receiver, the resultant link performance, with/without a selectable low noise amplifier (LNA), has a gain greater than 8/ -6 dB; a noise figure (NF) lower than 8 / 21 dB; an SFDR ~ 111/114 dB•Hz$^{2/3}$; and an RF bandwidth from 50 MHz through 20 GHz. The Micro ATX is dual use, suitable for outdoor commercial applications as well as tactical aircraft, surface and sub-surface vessels; built to operate in harsh environments and ambient temperatures from -40 to 70 degrees Celsius. Full specifications available at http://www.apichip.com/check-out-apics-complete-systems-today/ APIC also has externally modulated RFoF links up to 45 GHz and direct modulated links up to 6 GHz.



Micro ATx (20 GHz RFoF Transmitter)

Two salient points we wish to make about APIC and our advanced RFoF technology:

- Fiber to the antenna (FTTA): Many companies provide FTTA for both military and commercial applications. Most all of these have high noise figures (> 25 dB) which limits the system sensitivity. With APICs ultra low noise lasers and highly linear, high responsivity photodetectors we provide uncompromising signal fidelity – APIC can provide links with a low noise figure < 5 dB and spur free dynamic range > 110 dB•Hz$^{2/3}$. Additionally, our components are designed to function in harsh operating extremes.

- RF to 110 GHz: Emerging DoD requirements are pushing RF surveillance capabilities to 110 GHz. Multiple carriers are investigating 5G implementations at roughly 5, 15, 26, 68, 73 and 80 GHz bands. At present we have best in class components that can provide DC to 40 GHz without down converting and up to 65 GHz in the near future. We also have a solution to enable full spectrum surveillance to 110 GHz.

Most RFoF links are based on Amplitude Modulation. The links can be classified into <u>directly modulated</u> and <u>externally modulated</u>. In a directly modulated transmitter, the RF signal feeds directly into the laser

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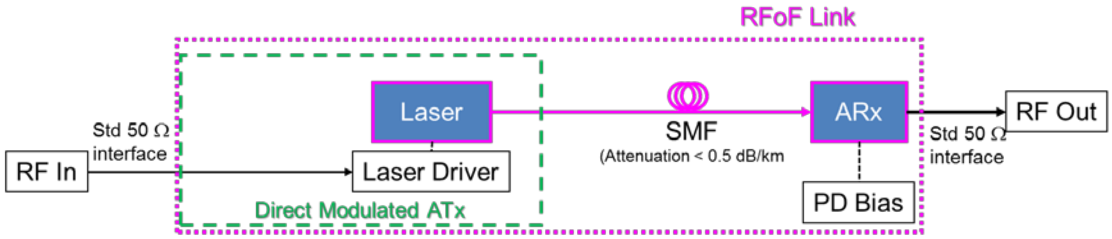
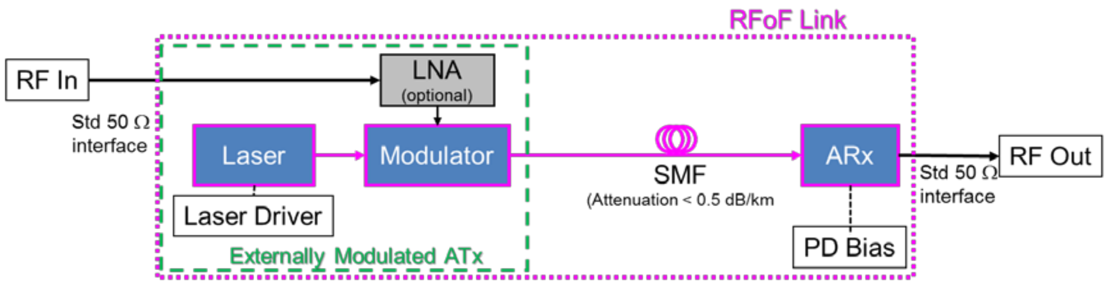
control circuitry which causes the laser to emit a modulated light signal. In an externally modulated link, the laser emits light with a constant amplitude. Downstream a Mach Zehnder diode modulates the light intensity in direct proportion to the RF signal.



Block diagram of a directly modulated RFoF link for 50 MHz to 6 GHz RF

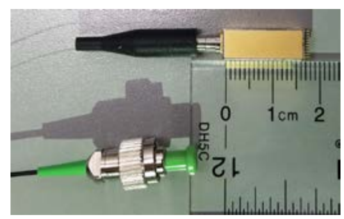


Block diagram of an externally modulated RFoF link.

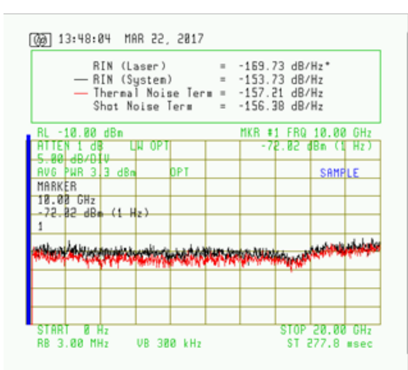
To achieve a low NF, high gain and high dynamic range the link components need to have the following qualities:

- Laser – high power and ultra low Relative Intensity Noise (RIN)
- Modulator (for externally modulated) – high efficiency (low Vπ)
- Detector – high power handling, high bandwidth, high linearity

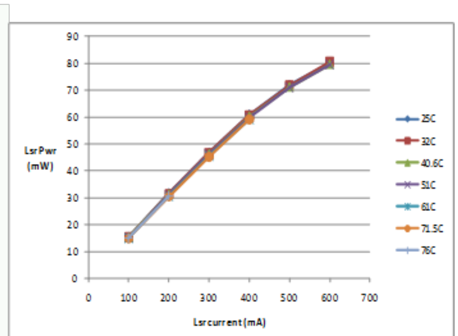
APIC high-power, ultra low noise CW lasers emit 80-100mW of optical power with a measured RIN of < -168 dB/Hz (shot noise ~ -170 dB/Hz).



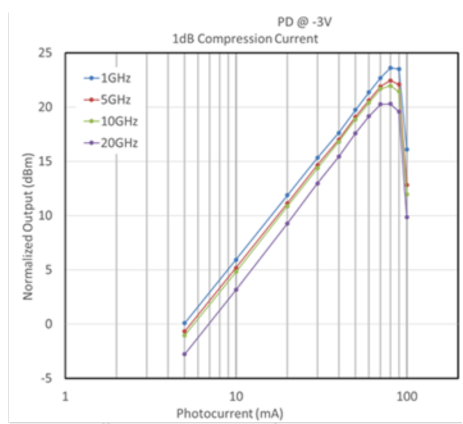
CW laser in XMD package



Laser RIN measurement



Laser output power vs input current



PD linear output vs photocurrent

APIC uses the best available lithium niobate Mach Zehnder modulators for external modulation and is working on developing advanced, small form factor modulators for future applications. APIC produces directly modulated analog transmitters which also incorporate ultra low noise lasers.

APIC photo detectors come in a variety of configurations; from DC to 10, 20 and 40 GHz that have a linear response up to 80 mW of optical power and responsivity of 0.85 A/W.

Why RFoF? Certainly the decision whether to employ an electrical conductor (COAX) versus a fiber optic link is application specific. At present, COAX is largely a less expensive option at lower frequencies (less than 5 GHz) and shorter distances (< 20 ft.). However that cost delta is narrowing as economies of scale lower the cost of photonic components and packaging. The fiber cable, itself, is inexpensive, costs much less than a COAX cable and is easier and more economical to install and maintain.

In terms of performance, fiber optics offers the following advantages over COAX:

- Signal attenuation in COAX increases with frequency, whereas in fiber, its < 0.5 dB per km independent of RF frequency. For many applications, 20 ft is the crossover where fiber outperforms COAX for signal attenuation.
- Fiber is much lighter and smaller in diameter than COAX.
- EMI/EMP – fiber is immune to EMI/EMP and emits no electromagnetic radiation.
- Fiber does not conduct electricity; it can electrically isolate the radio from the antenna and block a power surge from EMP and lightning strikes.
- Fiber is flexible and durable and will not degrade in wet, damp, corrosive environments.
- Fiber can be safely used in explosive environments; if damaged, it will not short, or spark.
- Several wavelengths of light/channels can be multiplexed on a single fiber without cross-channel interference. Sufficient separation can enable multiple levels of security (MLS) on same fiber.
- Multiple strands of "dark fiber" can be imbedded in a single cable for future use.

Why APIC? APIC Corporation is small business based in Culver City, California. Established in 1999, APIC performs a variety of research services, engineering design and manufacturing for photonic-electronic integrated components. Our core business is in III-V and silicon photonic device design, fabrication, and packaging. For the last 14 years, APIC has been performing advanced R&D and prototyping of robust photonic components to meet the demanding specifications of naval aviation under the technical oversight of NAVAIR, NRL and DARPA. The EW and integrated core processor (ICP) systems aboard the F-35, Joint Strike Fighter were the primary applications that motivated the development of our high-performance opto-electronic devices. As mentioned above, APIC's components outperform our competitors' in most every performance metric. This is due in part to APIC's control and quality management of every aspect of the design and manufacture of the photonic components; from the design of the epitaxy wafers to the masks and processes for fabricating the photonic chips to the design, assembly and test of the packaged modules.

APIC's product line and specifications are available at http://www.apichip.com/

For more information please contact Bob Walter, Director of Marketing and Sales; (703) 909-5811, sales@apichip.com.