Compact, High Power EIK sources used for ESR and NMR

Brian Steer, Mark Hyttinen, Albert Roitman, and Peter Horoyski
CPI Canada, Georgetown, Ontario, L7G2J4 Canada
Graham M. Smith, David R. Bolton, Paul A.S. Cruickshank, Duncan A. Robertson
School of Physics and Astronomy, University of St Andrews, Fife KY16 9SS, Scotland

***Abstract*—The EIKs described have demonstrated capability to provide mmW power suitable for improved ESR and NMR systems. The performance of EIKs at 94 GHz and 220 GHz is reviewed and possibilities for future improvement in performance, including increasing frequency, will be discussed. Presented data are supported by information provided by various academic and industrial customers.**

I. INTRODUCTION AND BACKGROUND

Leadership in Millimeter Wave Klystrons has been a continuing goal at CPI Canada. CPI first developed a line of high power reflex klystrons operating from 30 GHz to 320GHz, production continued until 1990 when they were phased out. The introduction of the high power Extended Interaction Klystron Oscillator (EIO) in 1967 followed in 1975, by the Extended Interaction Klystron Amplifier (EIK) continued the long-term interest in developing Millimeter Wave devices at CPI Canada. Since that time, CPI has developed and produced CW and pulsed EIKs from 18 GHz to 280 GHz. These EIKs are used at many academic locations where their simple and reliable operation in a compact size has proved their convenience.

CPI EIKs have demonstrated high reliability, long life and excellent stability in applications ranging from space, airborne and ground based radars, to high power satellite communications links.
Using existing technologies and materials such as EDM and M-type dispenser cathodes, EIKs may be reliably fabricated and reproduced to 700GHz with average powers of up to 2W.
The presentation will discuss the details of the EIK technology status and outline future developments.

II. EIK SUBSYSTEMS

EIKs are available with suitable high performance pulse or CW power supplies and may be configured as instrumentation amplifiers including cooling, protection and monitoring systems. Typical examples are presented for CW and pulsed instrumentation systems.

G-Band - 220 GHz 9.0 W CW EIK and Power Supply

Below is an example of the high duty cycle W-band EIK subsystem providing over 2 GHz of instantaneous bandwidth.

94 GHz 1500 pk watt EIK

6 inches

Power supply / Modulator
7 x 12 x 24 inches

Remote Control
19 inch rack mount

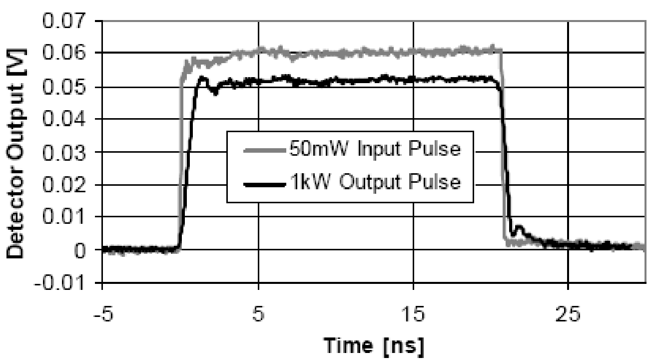
978-1-4244-2120-6/08/$25.00 ©IEEE.

III. RESULTS

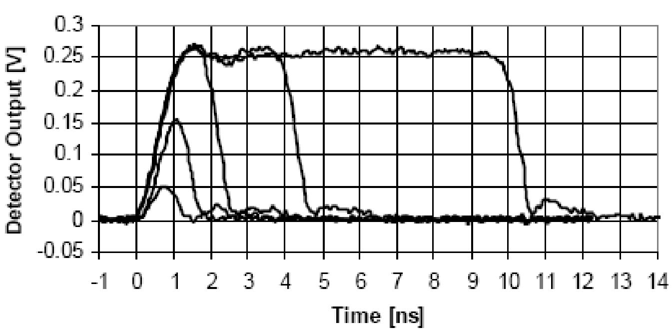
Pulsed EIK.

The paper will review results and performance achieved by various users related to ESR and DNP experiments. Specifically, RF pulse rise and fall performance, effects of bandwidth, gain and interpulse noise or "dark noise" in the EIK will be discussed. In experiments, pulses as short as half a nanosecond have been amplified to over 1kW by a CPI EIK which has a 1dB flat bandwidth of one GHz.

20ns 50mW input pulse and corresponding 1kW EIKA output pulse.



EIKA output pulses for a range of input pulse widths. The amplitude of the 10ns pulse corresponds to 1kW peak power.

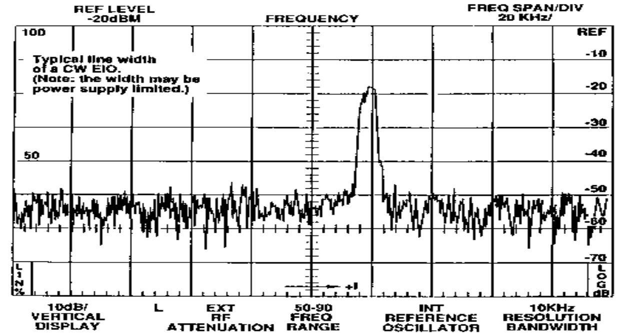


Below 1.5 nS the pulses do not reach full amplitude however at 0.5 nS ~250 watts is produced

CW EIO

The measured linewidth of a CW EIO is affected by power supply ripple and factors such as the resolution bandwidth of the spectrum analyzer and harmonic mixer used. We have measured the linewidth of a 142GHz EIO to be between 3 and 10 kHz, (0.050 parts /million) which may well be limited by power supply ripple. Frequency stability for an EIO is a function of temperature and power supply stability.

Typical Linewidth of a 140 GHz CW EIO



Data gathered from EIKs at various frequencies will be presented, demonstrating significant performance parameters of the EIK.

IV. CONCLUSION

The availability of EIK subsystems extends from 17 GHz to 280 GHz. In particular, for pulsed EIKs at 94 GHz, instantaneous bandwidth up to 2 GHz or peak power up to 3 kW is available. Note that in general, bandwidth and peak power are traded off against each other.

In comparison, 94 GHz EIKs have reached 400 watts at 300 MHz instantaneous bandwidth.

At 220 GHz, peak power of 100 watts and instantaneous bandwidth of 200 MHz is available or CW performance up to 10 watts and 200 MHz bandwidth.

Furthermore, modelling results suggest that 20 watts CW is achievable at 220 GHz, 1 watt at 460 GHz and 1,000 watts at 95 GHz.

The EIK also offers long lifetimes and coated dispenser cathodes have demonstrated life in excess of 27,000 hours at a peak current density of ~10 A/cm^2.

Chart of Typical Capability

Frequency	Pulsed Power	Average Power
35 GHz	3500 W	1000 W
95 GHz	3000 W	400 W
140 GHz	400 W	50 W
183 GHz	50 W	10 W
220 GHz	50 W	7 W
280 GHz	30 W	0.3 W

V. REFERENCES

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