receiving secondary coil contained inside the pump housing as depicted in Fig. 5. The system must ensure power transfer regardless of animal position. The maximum power required by the pump to operate at a maximum pumping rate is 25 mW. This power must be transmitted over a distance of 3-10 cm (distance between implanted pump and base station). A summary of the wireless power transfer requirements is provided Table 2.

Table 2: Wireless power transfer requirements

Operating Frequency	2 MHz
Maximum continuous power transfer	25 mW
Operating distance	3-10 cm
Load	7Ω-2.5kΩ
Coupling efficiency	0.5-5%

Power absorption in tissue is minimal below 10 MHz[18], a range in which tissue is essentially transparent to electromagnetic fields. Consistent with standards set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), an operating frequency of 2 MHz was selected. The maximum localized specific absorption rate (SAR) of 10 mW/g of body weight is regarded as the upper limit for occupational electromagnetic exposure. Any current induced in the tissue is primarily due to the magnetic field of the receiving coil rather than the electric field produced by the transmitting coil. With a maximum secondary coil power of 25 mW (maximum coil current of 5 mA) the dissipated power in the surrounding tissue due to this current is considered negligibly small.

The primary power transmitting circuit has a Class E topology (Fig. 6). A switching amplifier is used to drive a power transistor through a series-tuned primary coil. This is a standard topology for driving inductive links and has been implemented here for wireless power transfer to the implanted micropump.

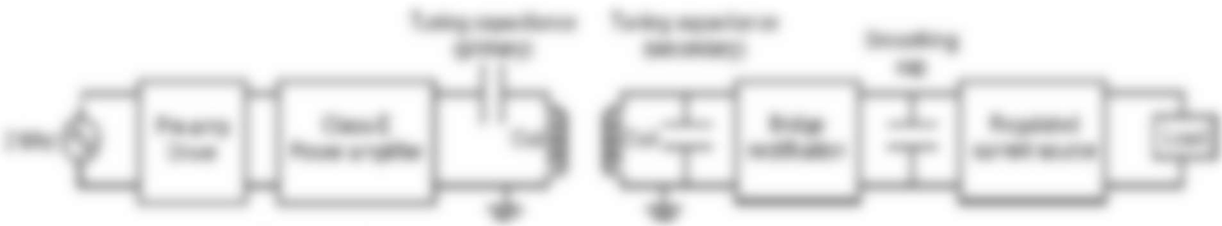

Figure 6: Primary and secondary inductive circuit block diagrams.

The receiving circuit is designed to be simple and space efficient while providing the necessary control over the electrochemical pump mechanism. Minimum component count and surface mount components are required. A full-wave bridge rectifier is implemented with low forward voltage Schottky diodes. DC regulation is provided by a parallel smoothing capacitor. A three-terminal low-voltage current source is utilized to achieve constant current regulation to the pump. The current source operates over a wide input voltage range (1-40 VDC) with 0.02 %/V current regulation.

Remote pump control requirement: There is currently no system that provides remote user control of implanted pumps. This has limited the ability of users to tailor and test delivery regimens in a direct and straight forward manner. **The ability to remotely control pump function is a feature that is highly attractive to users engaged in dose escalation/de-escalation, toxicity, behavior, brain mapping/imaging, addiction, and behavior triggered drug delivery studies.** We will investigate the first remote control drug delivery system capable of performing such studies in animals.

Multiple base stations will be controlled via a single computer, enabling dosing control of multiple implanted animals housed in separate cages (Fig. 7). Each base station provides power and control to the