Expert View

CUSTOM INTEGRATED CIRCUITS ENABLING ADVANCEMENTS IN IMPLANTABLE DRUG DELIVERY SYSTEMS

Asheesh Divetia of Cirtec Medical looks at how custom electronics are advancing implantable drug delivery systems – with precise drug administration, seamless connectivity to other devices and real-time monitoring of drug levels and patient responses. These device innovations are driving key improvements in therapeutic efficiency and patient outcomes.

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The advancement of implantable drug delivery systems is transforming medication administration, driven by breakthroughs in the miniaturisation of electronics and sensor technology and the growing need for tailored, long-term therapeutic solutions. Unlike conventional drug delivery methods, these systems emphasise precision, personalisation and automation, focusing on delivering the right dose at the right time and effective drug management. Implantable drug delivery systems, engineered for long-term operation within the body, use advanced technologies to ensure consistent and controlled dosing that enhances treatment accuracy and reduces the need for frequent interventions.

Customised electronics and integrated circuits (ICs) play a key role in this technology by enabling miniaturisation, improving power efficiencies and enhancing the functionality of these systems. Recent advancements in sensing and wireless technologies have also enabled real-time monitoring, improved data collection and seamless communication of this data to healthcare providers. Implantable drug delivery devices are proving invaluable in providing a wide range of medical therapies, including pain relief and chronic disease management.

THE EVOLUTION OF IMPLANTABLE DRUG DELIVERY SYSTEMS

The healthcare industry is increasingly recognising the need for more targeted, personalised and automated drug delivery systems. Conventional drug delivery methods, such as oral, topical or injectable delivery, generally deliver drugs in fixed doses without continuous monitoring or control, which can lead to undesired variability in drug levels in the body, wastage of the drug due to systemic administration and unnecessary side effects.

The development of implantable medical devices, such as pacemakers and neuromodulation systems, has paved the way for innovation in drug delivery. Recent advancements in engineering and manufacturing methods have made these devices more affordable and accessible, while they have also become more standardised and widely adopted, facilitating further developments in related fields, including implantable drug delivery. These manufacturing technologies, originally developed for other specific applications, are now being repurposed and customised for broader therapeutic uses.

Among the most transformative advances in implantable medical devices over the last two decades has been the integration of wireless communication within hermetically sealed packaging. Wireless components embedded in implanted electronics enable communication between the implanted device and external monitoring systems, allowing for easier data retention and retrieval, as well as higher bandwidth for data transfer. This functionality enables healthcare providers to monitor patients remotely, making it easier to track long term treatment efficacy and make necessary adjustments without requiring in-person visits.

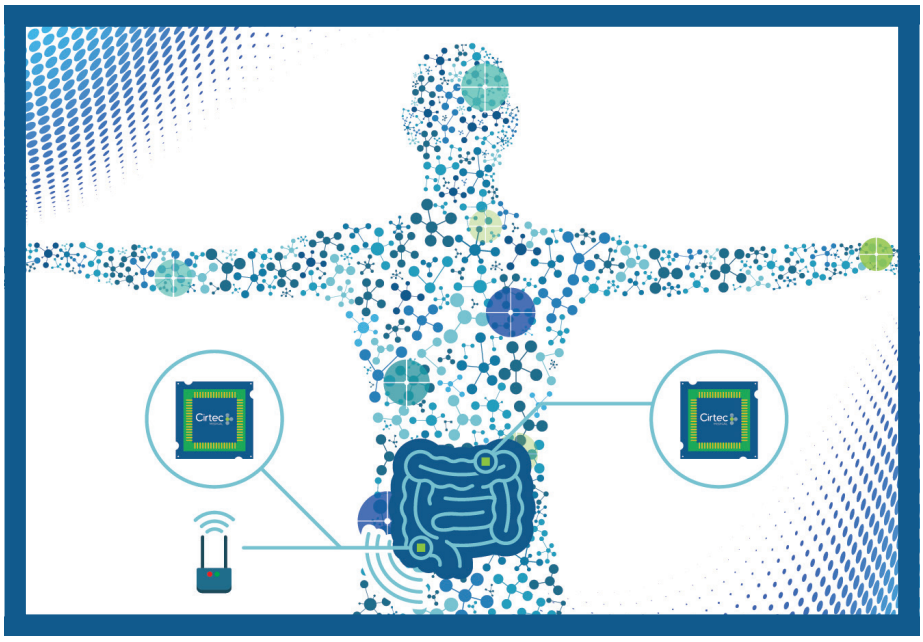

Figure 1: Advanced sensing chips enable precise health monitoring and treatment.

"WITH ADVANCEMENTS IN IC TECHNOLOGY ENABLING GREATER PRECISION, MINIATURISATION AND POWER OPTIMISATION, IMPLANTABLE DELIVERY SYSTEMS ARE REACHING NEW LEVELS OF FUNCTIONALITY AND PERFORMANCE."

CUSTOM IC TECHNOLOGY ENHANCES CLOSED-LOOP DRUG DELIVERY

With advancements in IC technology enabling greater precision, miniaturisation and power optimisation, implantable delivery systems are reaching new levels of functionality and performance. Custom ICs also enable the integration of various sensors to create a closed-loop system between the sensors and the implantable device. These miniaturised sensors allow real-time data collection on key physiological parameters, such as blood glucose levels, oxygen levels, blood pressure, temperature and hormone levels. These data can then be processed within the implanted device and directed to automatically adjust medication dosage in response to certain physiological changes and tailor it to individual patient needs (Figure 1).

For example, in an implantable insulin delivery system used for diabetes management, implanted sensors monitor blood glucose levels and relay that information to the insulin pump, which can then adjust the dosage as needed. This ensures that patients receive accurate, timely treatment without requiring constant supervision.

THE IMPACT OF SMART DRUG DELIVERY ON PATIENT OUTCOMES

Custom IC technology and miniaturised electronics play a pivotal role in advancing smart drug delivery systems that adapt to specific patient needs – a cornerstone of personalised healthcare. By integrating custom electronics that are engineered for high accuracy, low power consumption, wireless communication and extended durability, these systems can offer dependable, long-term performance within the body. This enables automated, fine-tuned administration of medications at optimised therapeutic levels, tailored specifically to individual needs, and significantly reduce the need for human intervention, thereby minimising the risk of dosage errors and enhancing overall patient safety.

Furthermore, the surging demand for smart drug delivery systems is prompting more manufacturers to develop and innovate in this space, driving competition and accelerating advancements in device technology. Such smart systems can extend their relevance across numerous healthcare applications, from managing chronic conditions to delivering highly targeted therapies. This versatility is instrumental in addressing the varied demands of personalised medicine and equipping healthcare providers with the tools to tailor treatment plans effectively. Implantable drug delivery systems can improve patient adherence, enhance treatment efficacy, reduce adverse side effects and contribute to lowering healthcare costs.

LOOKING AHEAD: ENHANCED DRUG DELIVERY

Looking ahead, advancements in custom electronics are set to drive more efficient, affordable and accessible monitoring and control capabilities, especially in healthcare. One promising application is implantable contraceptive devices, providing long-term birth control solutions in regions with limited access to conventional contraceptives. By reducing the cost and complexity of developing custom drug delivery devices, IC technology can help to make personalised medicine more globally attainable.

"ADVANCEMENTS IN CUSTOM ELECTRONICS ARE SET TO DRIVE MORE EFFICIENT, AFFORDABLE AND ACCESSIBLE MONITORING AND CONTROL CAPABILITIES."

Today, the development cycle for custom IC solutions is faster and more cost-effective than before. Manufacturers can create compact, sophisticated systems on a single chip, facilitating new implantable drug delivery devices. This makes specialised devices faster and cheaper to produce, broadening accessibility to diverse patient populations.

Custom ICs are paving the way for the future of implantable drug delivery, supporting precise and personalised administration. This technology is driving innovation as manufacturers respond to the growing demand for custom, automated healthcare solutions, intensifying competition and accelerating advancements. The road ahead holds immense potential, with IC-driven solutions continuing to break down barriers – offering better, more accessible healthcare for all.

Dr Asheesh Divetia

Asheesh Divetia, PhD, General Manager at Cirtec Medical, has over 20 years of experience in medical devices and a proven track record of driving strategic growth, fostering innovation and delivering high-quality engineering and manufacturing solutions. He holds a PhD in Biomedical Engineering from the University of California Irvine (US) and a BS in Electrical Engineering from the Indian Institute of Technology.

T: +1 408 395 0443 Ext 22923
E: asheesh.divetia@cirtecmed.com

Cirtec Medical
9200 Xylon Avenue North, Brooklyn Park, MN 55445, United States
www.cirtecmed.com

ABOUT THE COMPANY

Cirtec helps customers bring therapies to market quickly and cost effectively, from start-ups to Class II or III medical device manufacturers. The company offers services at every stage of the product development cycle, including design/development, pilot and clinical build, manufacturing and finished device assembly. Cirtec has a 30-year track record of developing medical devices fabricated under 21 CFR 820 and ISO 13485 quality standards. Cirtec helps customers bring products from concept to commercialisation on time, on budget and as seamlessly as possible.