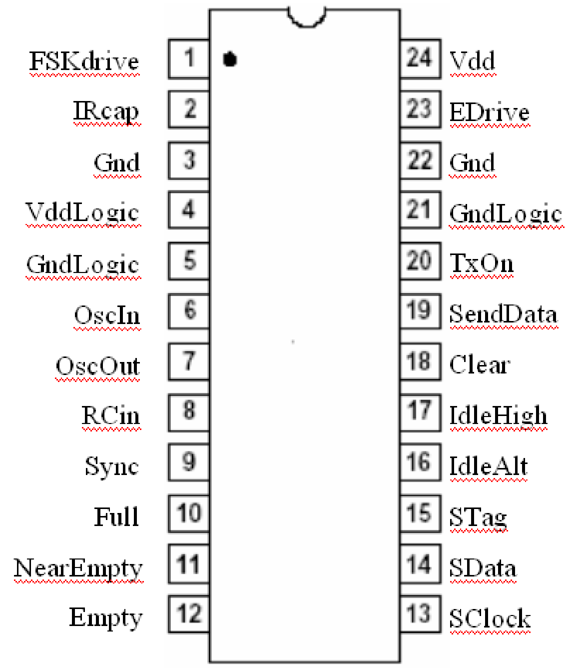
Sigenics Inc.

S5800C Class E Controller

The S5800C is a monolithic silicon controller and power driver for Class E control of a resonant circuit. Using a minimum number of external components, very large currents may be generated in an external resonant circuit. The power loss of the converter system depends primarily upon the Q of the external resonant circuit, and Amperes of resonant current may be generated using only mA of power supply current. The magnetic field created by the resonant inductor may be used to power remote or implanted electronic devices. *Using a patented method*, the S5800B is also capable of efficiently FSK modulating the inductor current, providing an inward magnetic telemetry data stream for control of remote electronic devices. The device may also be operated without the resonant circuit to provide an FSK modulated data stream over an optical link, and can drive an LED or LED array with up to 1 Ampere of current.

For use in the remote electronic devices, Sigenics also offers the S5801. This companion device recovers power and demodulated data from a magnetic field.



S5800C 24 pin DIP/SOIC

Note: The S5800C is identical to the S5800B, but the Tag sequence has been increased from 6 cycles to 8 cycles (see page 3).

Features

- Small size
- Maximum operating frequency ~ 10MHz
- Onboard FIFO with control pins for telemetry data buffering
- Microprocessor or PC parallel port interface to FIFO
- Telemetry modulator can also directly drive an LED for optical links
- Magnetic data link is immune to presence of metallic objects
- Operates from 2V to 5V power supply

Applications

- Passive RFID tag power
- Inductive heating systems
- Metal detectors
- Short-range magnetic data links
- Passive biomedical implant power and control

Absolute Maximum Ratings

Parameter	Min	Max	Units	Comment
Power supply voltage	-0.4	6.5	Volts	Vdd
Storage temperature	-35	135	degrees C	Limited by assembly materials
Electrostatic discharge	2000		Volts	Human-body model

Recommended Operating Conditions

Parameter	Min	Typ	Max	unit
Power supply	2.0	5.0	6.0	volts
Operating temperature	0		70	degrees C

Performance Specifications

Parameter	Min	Typ	Max	unit	comment
Power supply current		0.6		mA	
Drive (E, FSK) output current		3		Amperes	Gate drive to external power MOSFETs

Theory of Operation

A class E controller is designed to inject energy into a parallel resonant L-C circuit on a cycle-by-cycle basis to replace energy losses in the resonant circuit. Since the large circulating resonant currents are carried only by the passive resonant elements, system losses are determined primarily by the Q of the resonant circuit. The transistor switches in the controller system need only carry energy to replace the Q losses in the resonant L-C circuit, so other circuit losses are low.

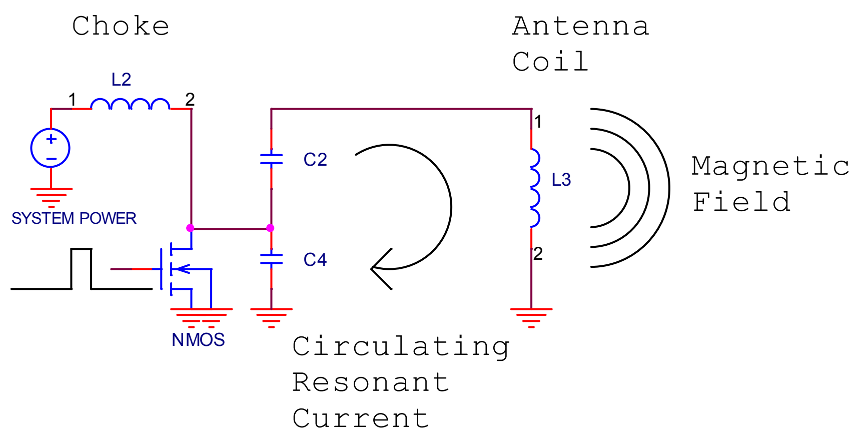


Figure 1. Class E Topology

The Class E converter is sometimes called a multifrequency or multiresonant converter because the resonance of the tuned circuit subtly shifts during the injection of additional energy. More detailed analysis of the Class E topology is available in the literature cited at the end of this data sheet. The Class E topology is shown in Figure 1. The frequency of operation is determined by L1, C1 and C2. Inductor L1 is a high Q coil designed to produce the magnetic field. Choke L2 acts as a current source to supply DC power to the circuit. The NMOS switching transistor replenishes the energy lost during each cycle of the resonant current. The timing and duration of the switch closure is critical to proper converter operation. Metallic, ferrous or conductive objects moving into the magnetic field generated by L1 will change the resonant frequency of the Class E network. The S5800C automatically adjusts the timing and frequency of the drive to compensate for this frequency shift and will maintain the converter at its optimum operating point.

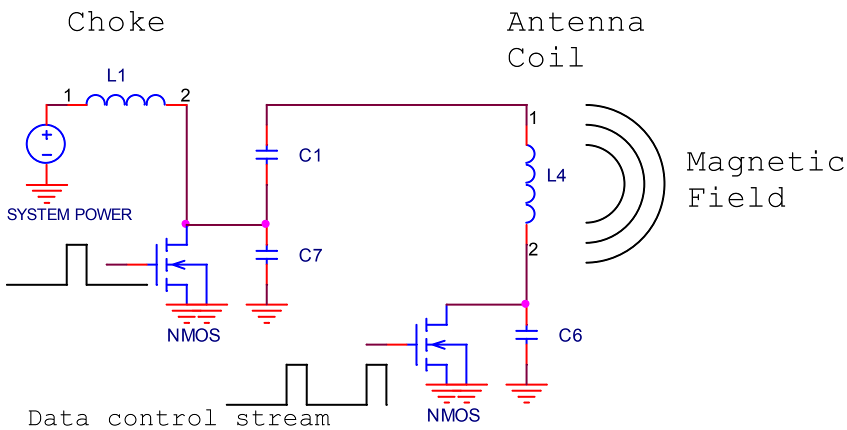


Figure 2. Class E Topology with FSK

If data transmission to remote devices is desired, the S5800C can control FSK modulation of the resonant current. By inserting an additional switch and capacitor C3 in the Class E circuit, the resonant frequency may be changed on a cycle-by-cycle basis. This allows the S5800C to frequency shift key (FSK) modulate the resonant frequency with digital data. This data may be used to control a remote or implanted device.

FSK Data Format

The S5800C uses Manchester encoding to send data. To be compatible with Sigenics NeuroTalk™ interface, a Tag input is also available. A Tag is an intentional violation of the Manchester encoding to establish an orthogonal control channel to a remotely controlled device. In the Sigenics NeuroTalk™ interface, Tags are used to signal the beginning of a serial command.

The S5800C uses four cycles of the resonant circuit to send each Data bit.
Data 1 : Two cycles at Flow followed by two cycles at Fhigh.
Data 0 : Two cycles at Fhigh followed by two cycles at Flow.

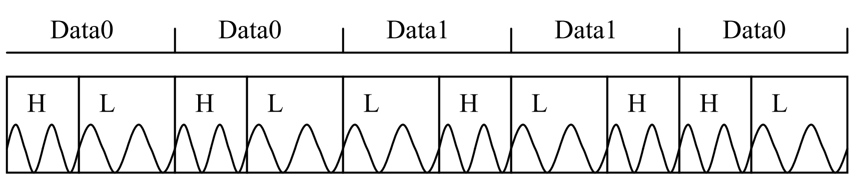


Figure 3. Example Data Stream

To send data using the S5800C, place the desired Data bit on the SData input with STag=0 (logic low), and clock the pair into the FIFO using the rising edge of SClk.

There are two types of Tags, "Tag0" and "Tag1", and they are defined thusly:
Tag0 : Eight cycles of Fhigh followed by eight cycles of Flow followed by a Data0
Tag1 : Eight cycles of Flow followed by eight cycles of Fhigh followed by a Data1

Note: The S5800C is identical to the S5800B, but the Tag sequence has been increased from 6 cycles to 8 cycles (see page 3).

The Data bit immediately after the six cycles in one state is called the "Tag Terminal Bit". The S5800B automatically generates these bits when a Tag is clocked into the FIFO. To comply with the NeuroTalk I specification however, the S5800C requires that the Tag terminal bit be clocked in explicitly. It therefore takes two SClk cycles to generate a Tag, which includes the Tag Terminal Bit.

To send Tags using the S5800C, set STag=1, and choose the type of Tag using the SData input. Clock the pair into the FIFO using the rising edge of SClk. Then clock in the Tag Terminal Bit. To generate a proper Tag, a Tag0 must be followed by a Data0, and a Tag1 must be followed by a Data1.

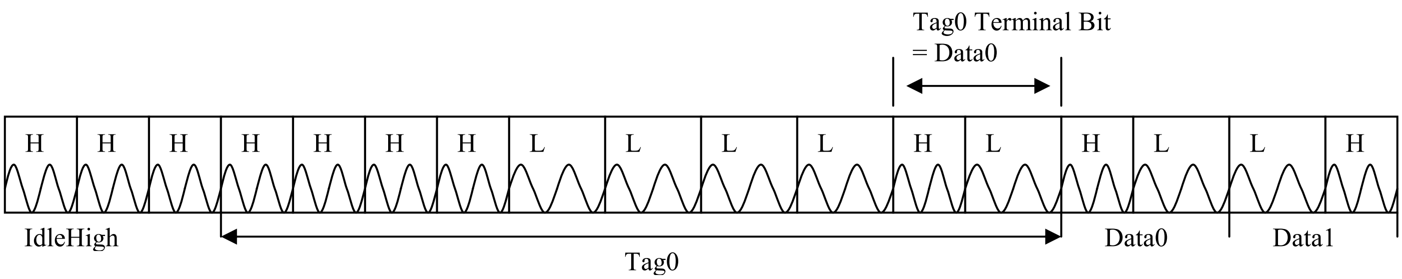


Figure 4. Example Data Stream with Tag0

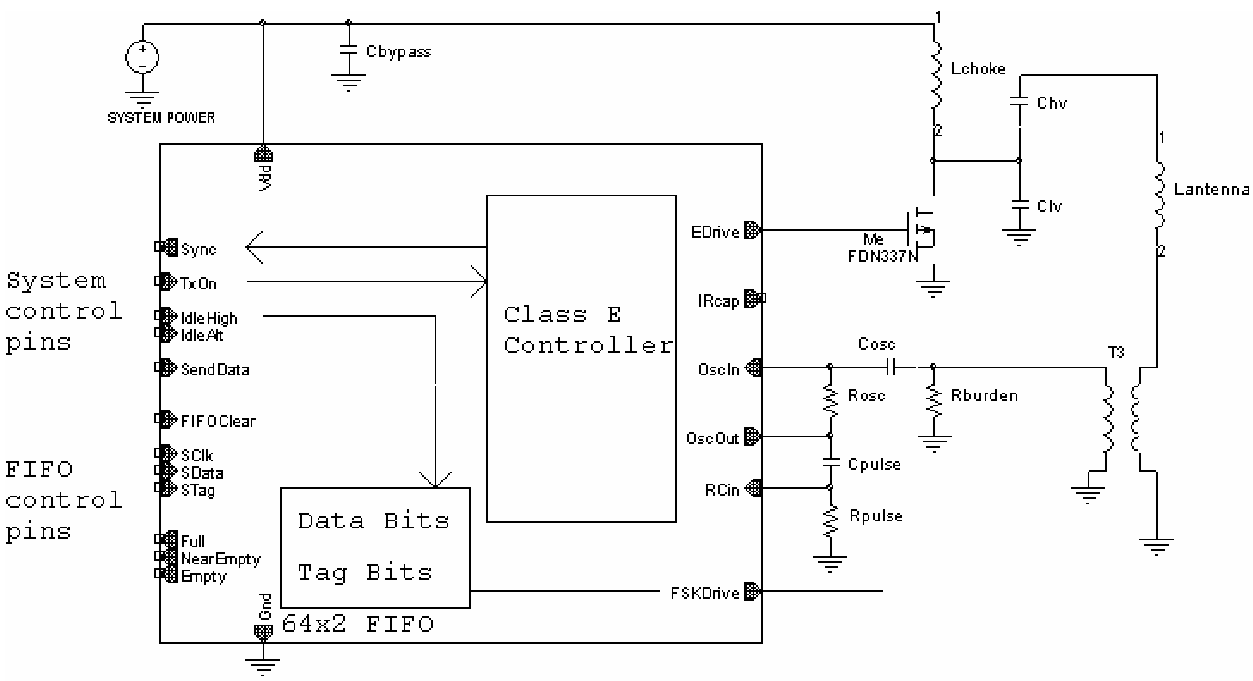


Figure 5. S5800C System with no FSK

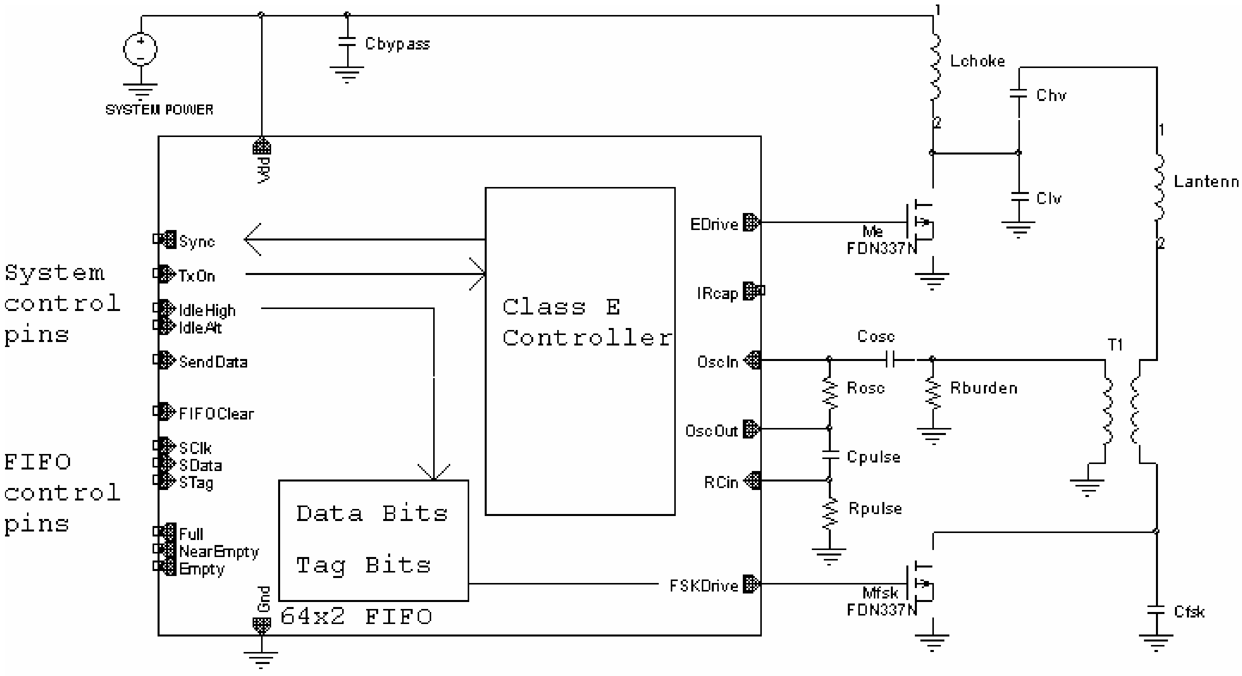


Figure 6. S5800C System with FSK

Figure 6 shows a diagram of an FSK system using the S5800C with external components. Lantenna, Chv, Clv determine the low operating frequency (Flow) of the converter. When Cfsk is unshorted by FSK switch Mfsk, the operating frequency of the converter shifts upward to the high operating frequency (Fhigh).

System Control Pin Descriptions

These pins are used to control the basic operation of the converter:

Sync This output provides a logic-level square wave at the operating frequency of the converter.

TxOn A logic high level at this input turns the converter on, a low level shuts the converter down.

IdleHigh A logic high level at this input will cause the converter to run at Fhigh when the data FIFO is empty. If this input is low, the converter will run at Flow with an empty FIFO.

IdleAlt A logic high level at this input will cause the converter to run with two cycles of Fhigh followed by two cycles of Flow when the data FIFO is empty. While the FIFO remains empty, this pattern will repeat indefinitely. Changing the state of IdleHigh will invert the phase of the Flow/Fhigh alternating pattern. The IdleHigh input could be used therefore to PSK modulate the carrier if desired.

FIFO Control Pin Descriptions

The FIFO is a two bit wide, 64 bit deep circular buffer. One of the two bits is used for “Data” and the other bit is used for “Tag”. The operation of Tag will be described in the Data Format section below. On the rising edge of the SClk input, data appearing at the Data and Tag inputs is stored at the input of the FIFO. When loading the FIFO, the Full output will go high when all 64 FIFO locations have been loaded with data. If the SendData control pin is held to a Logic low, data will not be transferred to the converter output and the converter will produce the Idle pattern at its output. When SendData is brought high, the FIFO empties into the converter output as the converter runs and FSK modulates The Data and Tag bits are removed from the output of the FIFO. When the FIFO contents drop to 16 Data/Tag pairs (1/4 full) or less, the NearEmpty output goes high in time allow the user to reload the FIFO before the FIFO completely empties. If the FIFO is allowed to completely empty, the Empty output goes high, and the converter idles at Flow or Fhigh depending on the state of the IdleHigh input.

FIFOClear	A logic high on this input clears the FIFO contents.
SendData	A logic high on this input allows the FIFO to empty while modulating the converter output.
SClk	On the rising edge of this input, SData and STag are clocked into the FIFO.
SData	The Data data input.
STag	The Tag data input.
Full	Goes high when the FIFO is filled with 64 data pairs.
NearEmpty	Goes high when the FIFO has emptied to ¼ full or less.
Empty	Goes high when FIFO is empty.

Class E Controller Operation

Referring to Figures 5 and 6. In order to start the Class E converter, external components Rosc and Cosc form a relaxation oscillator using internal Schmidt trigger U1. The converter is set to free-run at a frequency lower than the normal operating frequency of the converter, typically 40-80% of the resonant frequency of the L-C network. Current transformer T1 is used to measure the resonant current with very low loss. Burden resistor Rburden converts the current to a voltage. After resonant feedback is established through the current sense transformer, the transformer output overdrives U1 through Cosc resulting in a closed-loop control of the converter frequency. Network Rpulse/Cpulse set the width of the EDrive pulse to the Class E switch Me. The width of this pulse is adjusted for optimum converter performance, the optimum width being dependent on resonant Q, Vdd and frequency of operation.

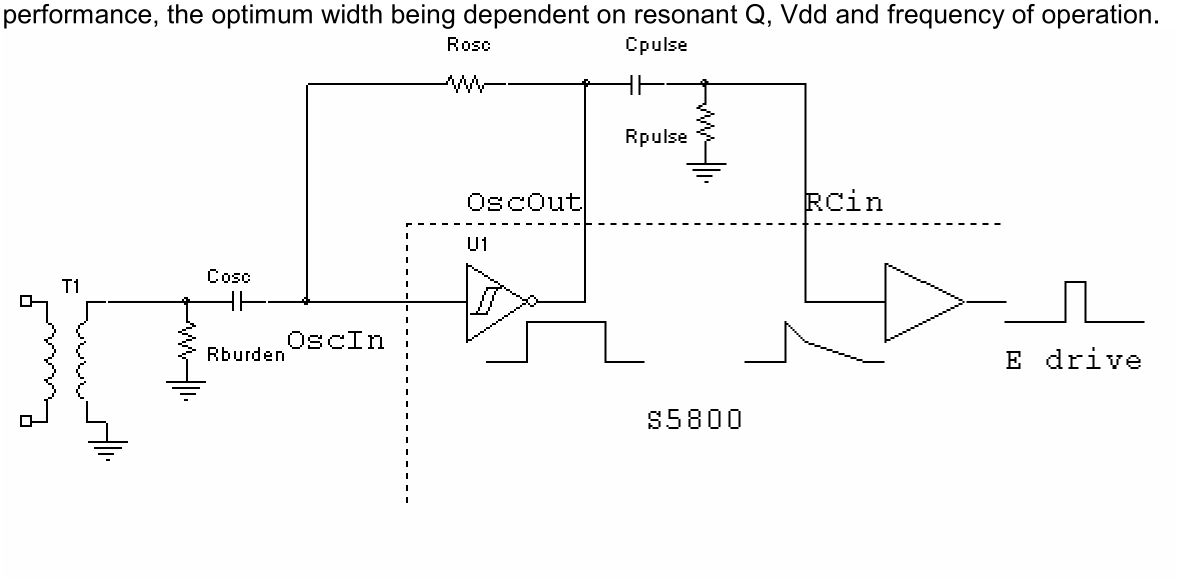


Figure 7. S5800C Oscillator Detail

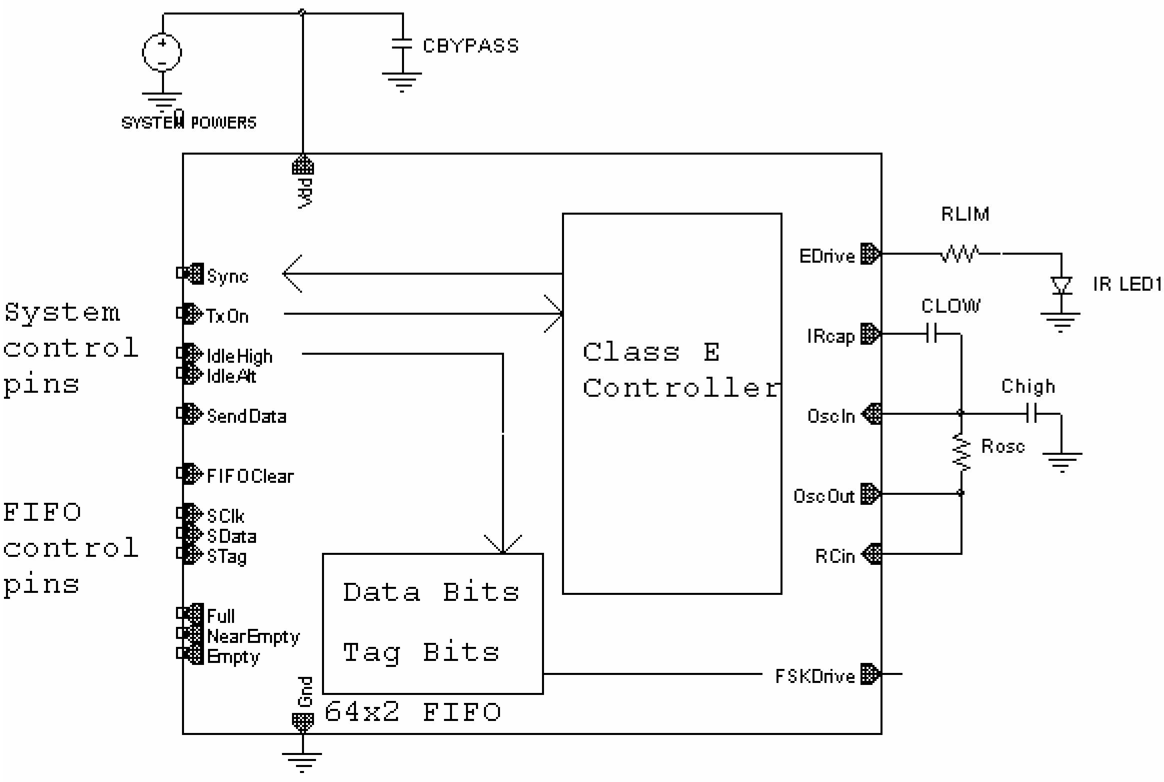


Figure 8. S5800C Driving an IR LED

The S5800C may also be used without magnetics to drive an LED to generate an FSK modulated optical stream as shown in the figure above. The IRcap terminal connects Clow in parallel with Chigh to instantaneously lower the LED pulse frequency at the appropriate times.

References

J. Song, A. Greenwood, I. Batarseh (1996) Analysis and Design of Zero-Voltage-Switching Class-E Converter
apec.engr.ucf.edu/publications/ conferences/ieee_se/conf_twenty_nine.pdf

Troyk, P.R., Schwan, M.A., (1992) Class E driver for transcutaneous power and data link for implanted electronic devices, Medical Biological Engineering and Computing., vol. 30, pp.69-75.

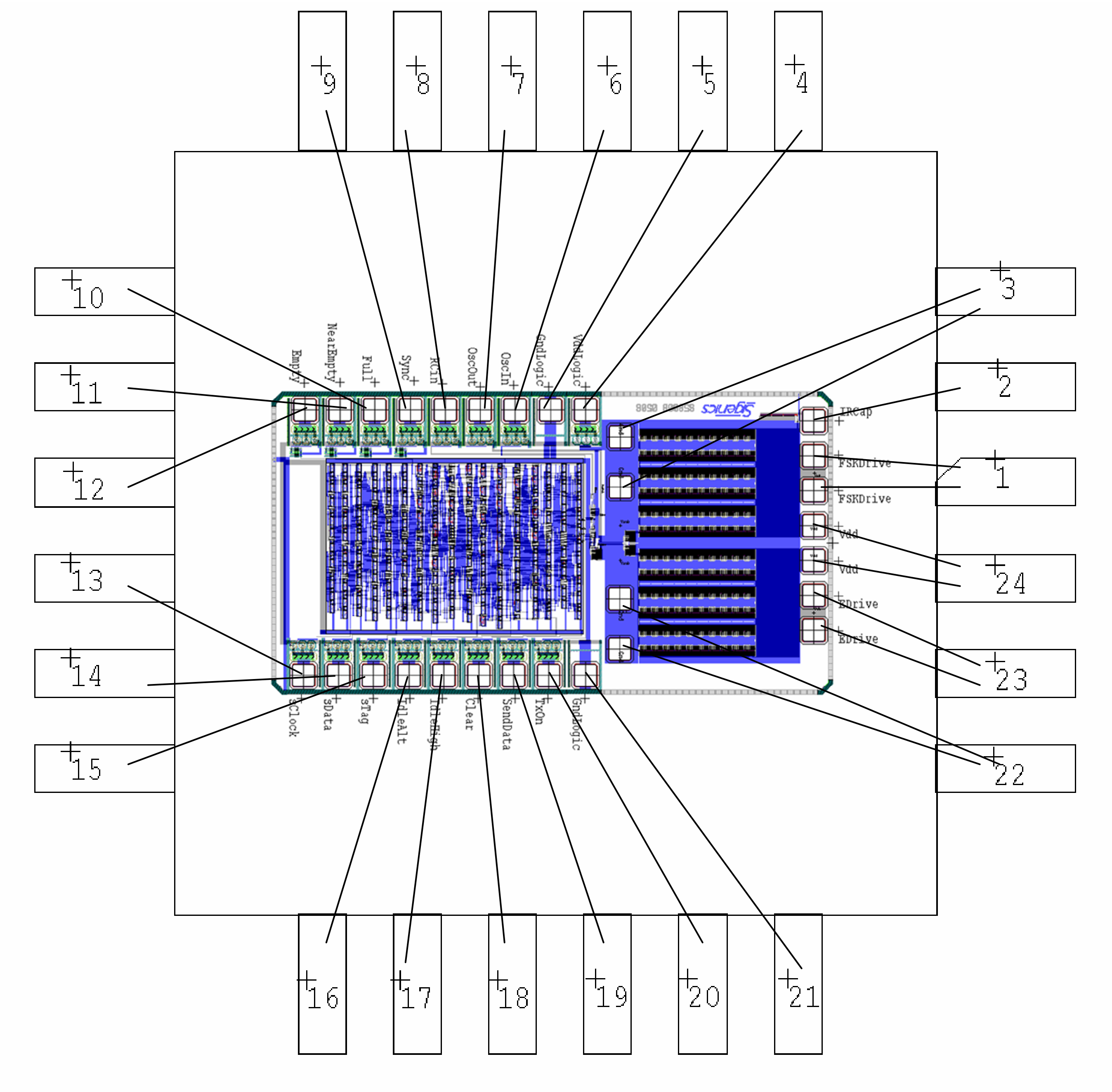
Troyk PR, Schwan MA. (1992). Class E driver for transcutaneous power and data link for implanted electronic devices. Med. Biol. Eng. Comp. 30: 69-75

Troyk, P.R., Schwan, M.A., (1992) Closed-loop class E transcutaneous power and data link for microimplants, IEEE Trans. Biomed. Eng., vol.39, no.6, 589-599.

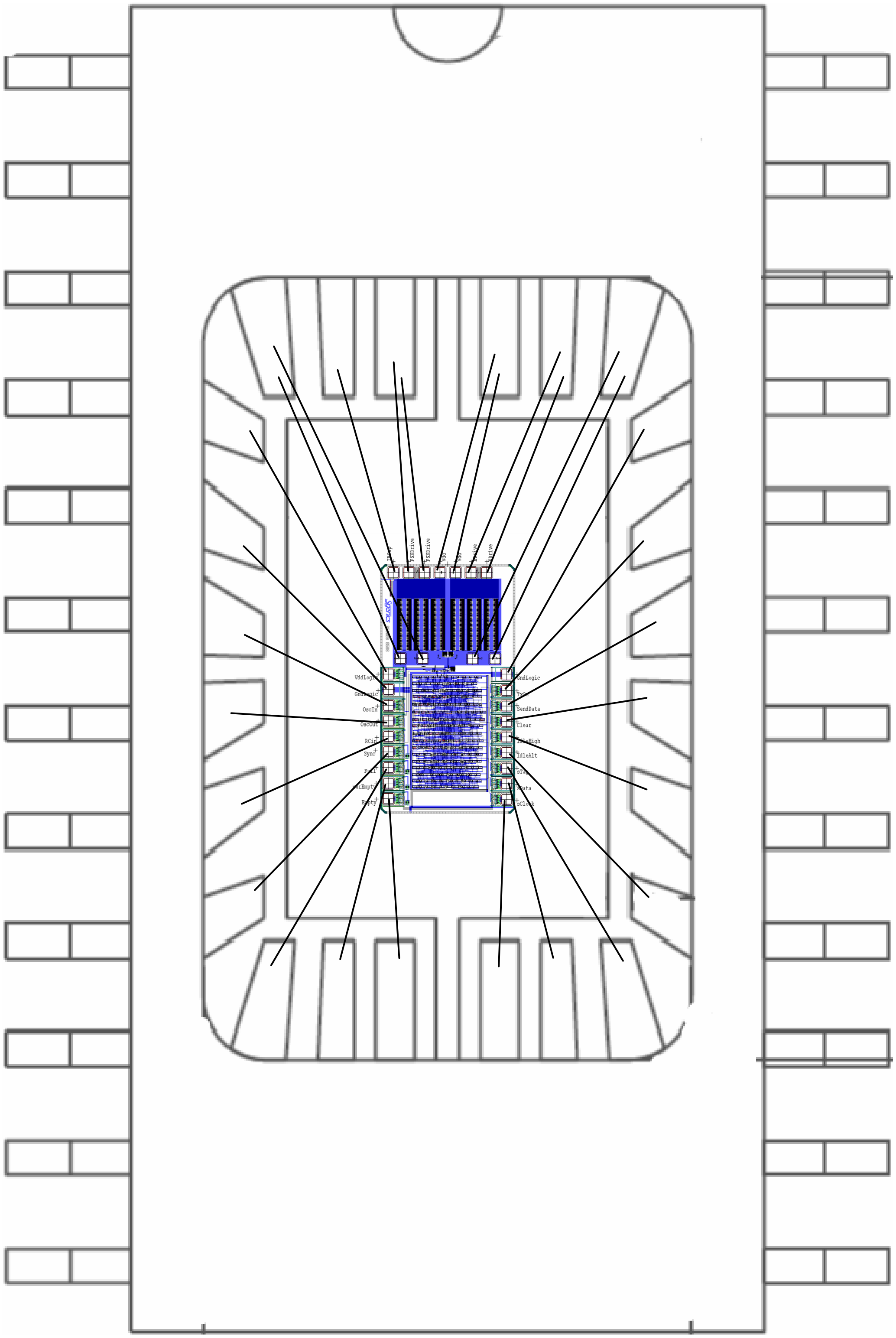
Schwan, M., Troyk, P., (1995) Suspended carrier modulation for transcutaneous telemetry links, Proceedings 13th International Symposium on Biotelemetry, March, Williamsburg, VA pp. 27-32.

Troyk, P., Schwan, M., (1995) Modeling of weakly-coupled inductive links, Proceedings 13th International Symposium on Biotelemetry, March, Williamsburg, VA pp. 63-68.

Mechanical Drawings



S5800C Bonding Diagram / 24 pin dip



S5800C Bonding Diagram / 24 pin SOIC

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