114, 116, and 118 are coupled to outputs A, B, C and D of microprocessor 38 respectively. The microprocessor 38 uses the four signals A, B, C, and D to transition the LCD 32 between the opaque state and the transparent state. The microprocessor 38 activates all four transistors 112, 114, 116, and 118 by driving the signals A, B, C and D to a high level to transition the LCD 32 into the transparent state. When transitioning the LCD into the opaque state, the microprocessor 38 alternatively driving signals A and B high and C and D low, or vice versa, to prevent the LCD 32 from polarizing.

The liquid crystal layer 96 is capable of switching between a transparent state (ON) or an opaque state (OFF). The liquid crystal layer 96 is coupled to and controlled by the microprocessor 38 and the control circuit 110. When data is to be down-loaded, the microprocessor 64 of the external communication device 14 causes the LED 50 to turn on and off at a high frequency, resulting in a carrier signal 98 being transmitted into the patient. The microprocessor 38 of the internal communication device 12 modulates the carrier signal 98 with the data stored in the SRAM 42 by switching the LCD 32 between the transparent and opaque state. For example, when transmitting a logical one, the LCD 32 is placed in the transparent state, and the photodetector 52 of the external communication device 14 receives a reflected carrier signal 100 reflected off the mirrored layer 92 of the LCD 32. On the other hand, when transmitting a logical zero, the crystal layer 96 of the LCD 32 is made opaque. The photodetector 52 therefore does not receive the reflected carrier signal 100 during the transmission of a logical zero. In this manner, the information contained in the SRAM 42 of the internal communication device 12 is transmitted to the external communication device 14 through the skin of the patient. The reflected carrier signal 100 is modulated in accordance with any of the above-mentioned encoding schemes.

Referring to FIG. 5, a signal 98 as transmitted by LED 50 and a reflected into the body of the patient and a reflected carrier signal 100 as reflected by LCD 32 is shown. In one embodiment, the frequency of carrier signal 98 is 5 KHz or greater. The Table III below provides the DATA transferred (either a "1" for logical one or a "0" for logical zero) external to the body and the STATE of the LCD 32 (either "T" for transparent or "O" for opaque) for eleven time intervals $t_0$ through $t_{10}$ respectively as illustrated in figure.

TABLE III

| Time Interval | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ | $t_6$ | $t_7$ | $t_8$ | $t_9$ | $t_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DATA | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| STATE | T | O | T | O | O | T | O | O | O | T | T |

Once the down-load operation has been completed, the data needs to be transferred to the processing station 16. Data can be transferred to the processing station either automatically, at a pre-designated time, or upon the direction of the patient. For example, the clock 54 of the external communication device 14 may be used to inform the microprocessor 64 to transmit the data through the transmitter/receiver 56 to the processing station at a specific time or times each day. Alternatively, the patient can over-ride the automatic transmission feature, and direct the microprocessor 64 to transmit the data on command. To initiate this feature, the patient is required to activate switch 60d, which causes the data stored in the microprocessor 68 to be transferred to the processing station 16 through the transmitter receiver 56.

The external communication device 14 and the internal communication device 12 need to be properly aligned before correct data communication can take place. To achieve alignment, the patient places the external communication device 14 in the relative proximity of the internal communication device 12 located beneath the skin of the patient. The patient subsequently activates switch 60*e*, which causes the external communication device 14 to transmit the third predefined string of bits into the body of the patient. The internal communication device 12 reads the third predefined string of bits, and compares it with a designated string of bits stored in the microprocessor 38. The external communication device 14 then transmits a carrier signal 98 into the patient. The internal communication device 12, using the same method as described above, modulates the carrier signal 98, and transmits a reflected carrier signal 100 with the third predefined string of bits modulated thereon back to the external communication device 14. If the bit string transmitted and received by the external communication device 14 is the same, then the two communication devices 12 and 14 are aligned. If a mis-match occurs, the patient is required to adjust the position of the external communication device 14, and to repeat the alignment steps, until a match occurs. In one embodiment, a visible marker, such as a tattoo or other designator, may be used to help the patient align the two communication devices. When alignment is achieved, the LED 62*g*, or alternatively an audio signal such as a chime, is activated informing the patient that it is permissible for either an up-loading or a down-loading operation to take place.

With the present invention, the majority of the energy required for communication between the internal communication device 12 and the external communication device 14 is supplied by the external communication device 14. Since the internal communication device 12 uses very little energy, the battery life of the device is conserved. Further, since the time period required to modulate both a logical one and a logical zero are both one clock cycle t, the rate of data transfer is improved. While the present invention has been described in relationship to the embodiments shown in the accompanying figures, other alternatives, modifications and embodiments will be apparent to those skilled in the art. For example, high frequency carrier signal 98 can be replaced with a DC carrier signal. Transdermal communication can also be accomplished by other forms of energy besides light, such as RF, sound, or any other type of energy. Some or all of the LEDs 62*a* through 62*e* can be replaced by an audio signal, such as an alarm or a chime. Further, some of the functionality and associated circuitry of the of the switches 60*a* through 60*e* can be moved to the housing 70. It is intended that the specification be only exemplary, and that the true scope and spirit of the invention be indicated by the following claims.

I claim:

1. A transdermal communication system; comprising:

an internal communication device configured to be implanted inside the body of a patient;

an external communication device configured to be located outside the body of the patient;

an external transmitter, coupled to the external device, and configured to transmit a carrier signal into the body of the patient during communication from the internal communication device to the external communication device;

an internal modulator, coupled to the internal communication device, and configured to modulate the carrier