

Claim Chart For Infringement of U.S. Patent No. 7,496,342 by TI Chips

Claim 18	TI Chips
A method for down-converting an electromagnetic signal, comprising the steps of:	TI directly infringes (literally and/or under the doctrine of equivalents) the '342 patent by making, using, selling, offering for sale, and/or importing in/into the United States products covered by at least claims 18-23 of the '342 patent. TI products that infringe claims 18-23 of the '342 patent include TI wireless chips (e.g., cellular, Wi-Fi and/or Bluetooth chips) including, without limitation, the AFE76XX series, AFE77XX series, AFE79XX series, AFE80XX series transceivers, and any other TI chip (collectively, "TI Chips") that is capable of down-converting an electromagnetic signal as claimed in the '342 patent. On information and belief, each TI Chip includes at least one or more switches/transistors that sample a carrier signal, one or more capacitors that store non-negligible amounts of energy from a carrier signal, and one or more resistors providing a low impedance load(s). On information and belief, the structure, function, and operation of TI Chips are substantially similar to one another with respect to the claims at issue. On information and belief, the TI Chips are described, in part, in the IEEE paper entitled "A Fully Integrated 2x2 b/g and 1x2 a-Band MIMO WLAN SoC in 45nm CMOS for Multi-Radio IC," by R. Kumar et al., 2013 <i>IEEE International Solid-State Circuits Conference Digest of Technical Papers</i>, San Francisco, CA, USA, 2013, pp. 328-329 (hereinafter referred to as the 2013 IEEE paper). On information and belief, each TI Chip performs a method for down-converting an electromagnetic signal (e.g., high frequency RF signal) to a lower frequency signal (e.g., baseband signal). The method is performed on the receiver side of each TI Chip. For example, the AFE76XX "is a family of high performance, quad/dual channel, 14-bit, integrated RF sampling analog front ends (AFEs) with 9 GPS DACs and 3 GPS ADCs, capable of synthesizing and digitizing wideband signals."¹ Accordingly, each TI Chip is configured to receive an electromagnetic signal (e.g., high frequency RF signal). In order to process such a signal, each TI Chip must necessarily down-convert the electromagnetic signal to a baseband signal.

¹ https://www.ti.com/lit/ds/symlink/afe7686.pdf?ts=1701875653400&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FAFE7686; see also, e.g., https://www.ti.com/lit/ds/symlink/afe8004.pdf?ts=1701875867735&ref_url=https%253A%252F%252Fwww.google.com%252F%252Fhttps://www.ti.com/lit/ds/symlink/afe7799.pdf?ts=1701875830461&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FAFE7799; https://www.ti.com/lit/ds/symlink/afe7920.pdf?ts=1701876119308&ref_url=https%253A%252F%252Fwww.google.com%252F%252F.

(1) receiving an information signal;
signal;

Each TI Chip receives an information signal (e.g., RF information signal, shown in the red box) along the red path.

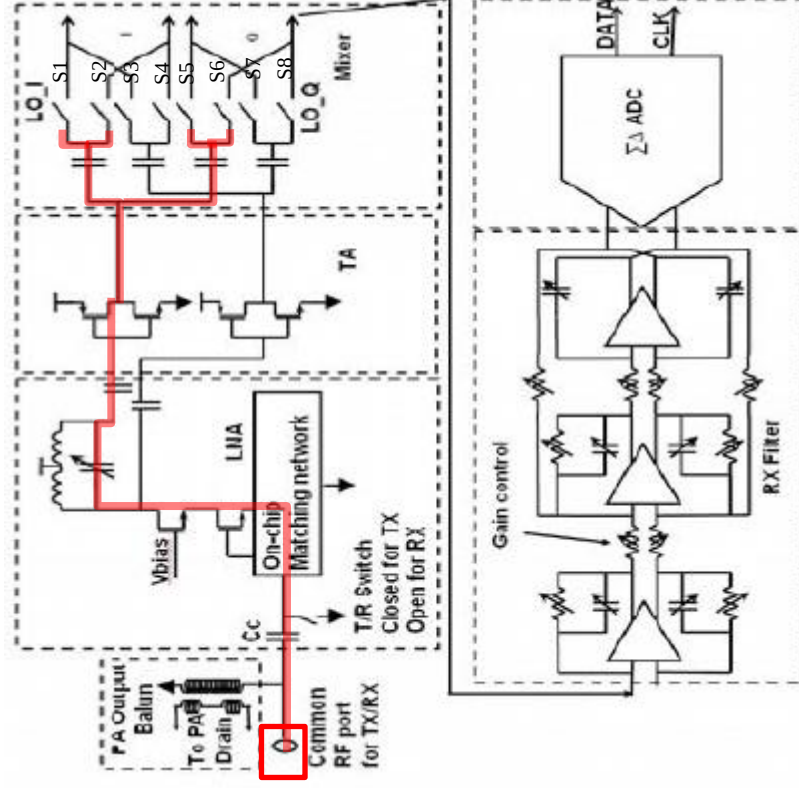


Figure 19.1.4 of 2013 IEEE paper.

(2) inverting the information signal to generate an inverted information signal;

On information and belief, each TI Chip inverts the information signal (e.g., RF information signal, shown in the red box) via e.g., an LNA to generate an inverted information signal (e.g., inverted RF information signal, shown along the orange path).

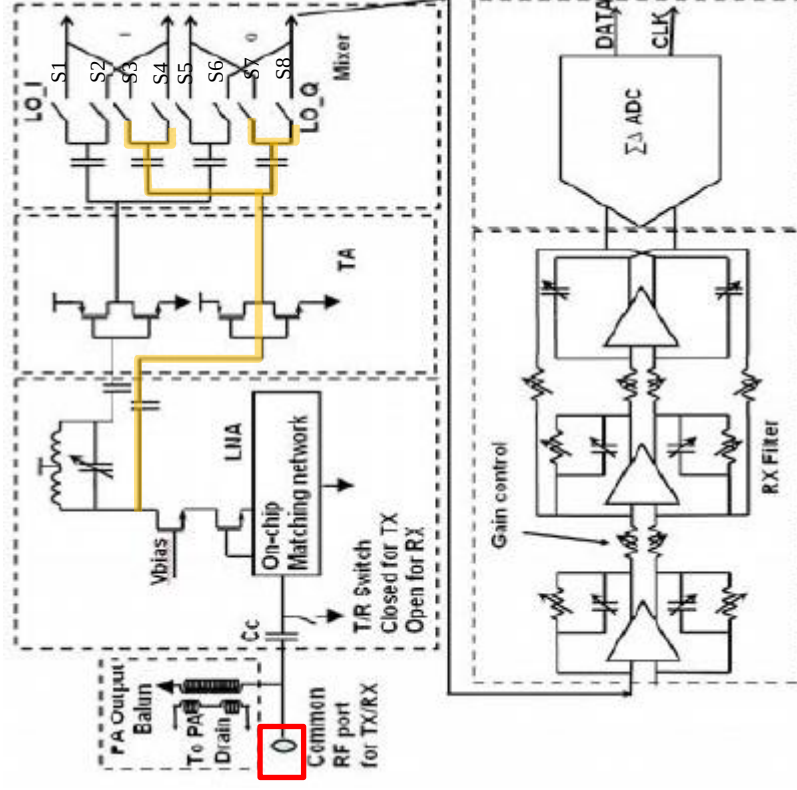


Figure 19.1.4 of 2013 IEEE paper.

(3) electrically coupling the information signal to a first capacitor and the inverted information signal to a second capacitor;

Each TI Chip electrically couples the information signal (e.g., RF information signal, represented by the red path) to a first capacitor (e.g., capacitor C1, shown in the green box) and the inverted information signal (e.g., inverted RF information signal, represented by the orange path) to a second capacitor (e.g., capacitor C2, shown in the green box).

As shown below, each TI Chip includes a first switch (e.g., switch S1, shown in the purple box) coupled to the information signal (e.g., RF information signal, represented by the red path) and to a first control signal (e.g., LO_I+, represented by LO_I in the orange box).

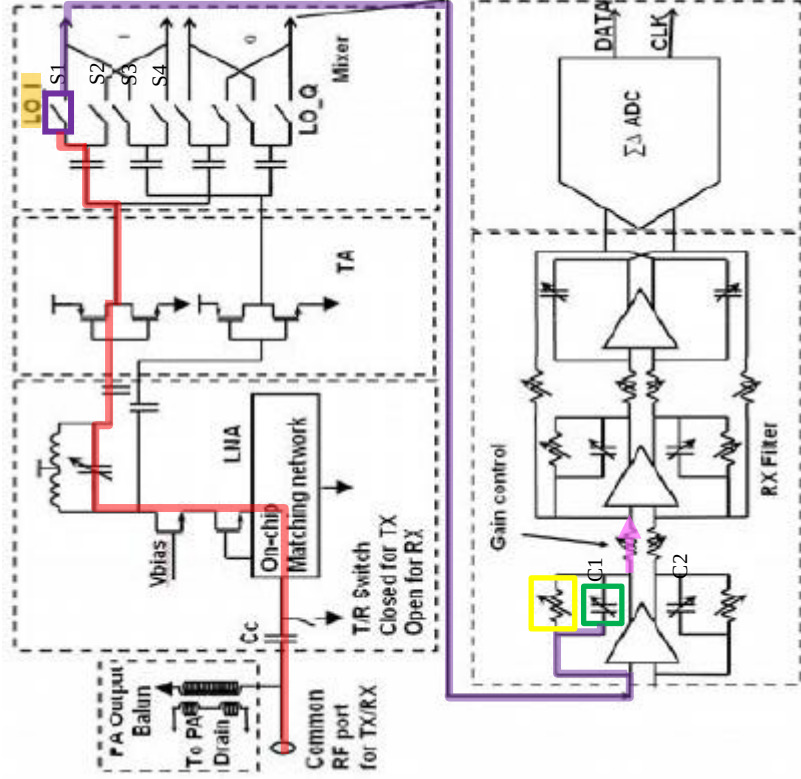
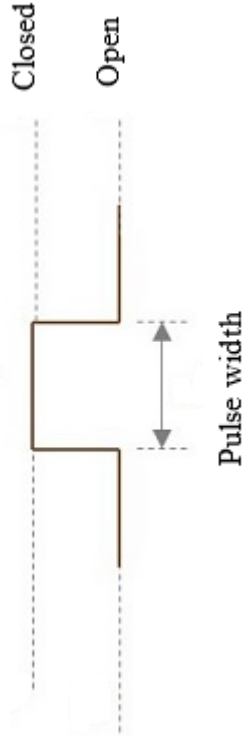


Figure 19.1.4 of 2013 IEEE paper.

Switch S1 (purple box) includes transistors that operate as a switch with switching frequency and duty cycles controlled by LO_I+ (orange box). In particular, switch S1 (purple box) periodically opens and closes, thereby controlling the current flow of RF information signal (red path) in the circuit. The time period for which switch S1 (purple box) is open/closed is determined by LO_I+ (orange box). Specifically, LO_I+ (orange box) enables (i.e., closes) switch S1 (purple box) during an aperture thereof. An aperture describes the pulse width of the control signal (i.e., the length of activation within the signal) when the switch is closed. The diagram below represents an exemplary waveform of control signal LO_I+.



When switch S1 (purple box) is ON (closed), current can pass through the switch S1; when the switch is OFF (opened), current is blocked from passing through the switch. The switch S1 is turned ON (closed) by sending control signal LO_I+ to the switch at an independent control input. The switch is kept ON (kept closed) for the duration of the signal pulse (i.e., during a sampling aperture of the pulse). Successive pulses of LO_I+ (orange box) therefore recursively close/open switch S1 (purple box). The recursive closing/opening of switch S1 (purple box) periodically couples the RF information signal (red path) to a first capacitor C1 (green box). During an aperture of LO_I+ (orange box), for example, switch S1 (purple box) closes and energy from RF information signal (red path) is directed to capacitor C1 (green box) along the purple path.

Likewise, as shown below, each TI Chip includes a second switch (e.g., switch S4, shown in the purple box) coupled to the inverted information signal (e.g., inverted RF information signal, represented by the orange path) and to a second control signal (e.g., LO_I-, represented by LO_I in the orange box).

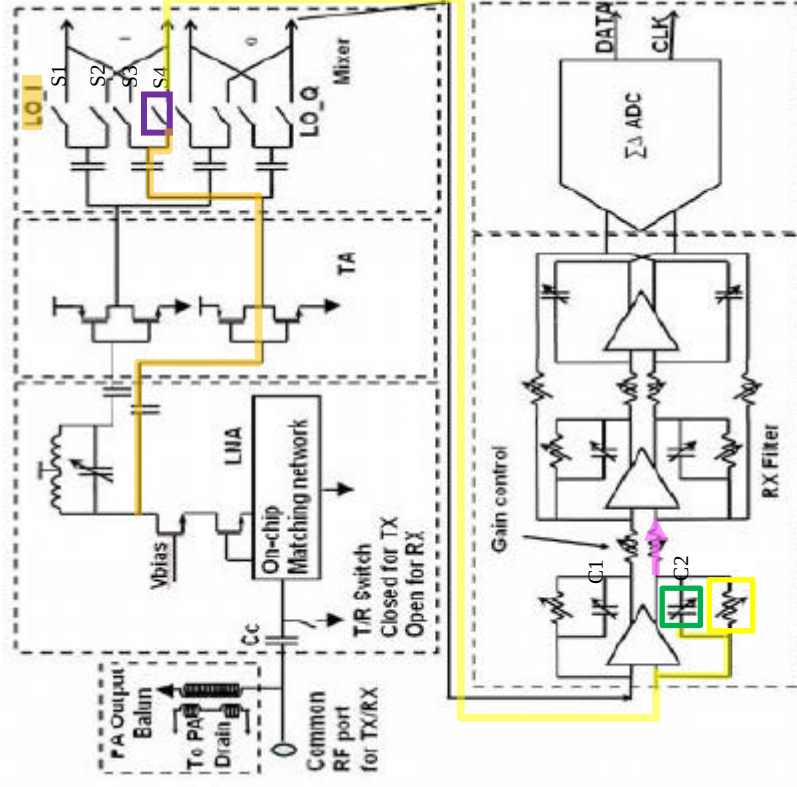
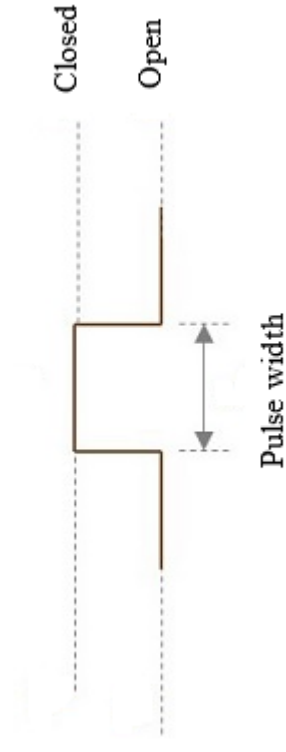


Figure 19.1.4 of 2013 IEEE paper.

Switch S4 (purple box) includes transistors that operate as a switch with switching frequency and duty cycles controlled by LO_I- (orange box). In particular, switch S4 (purple box) periodically opens and closes, thereby controlling the current flow of inverted RF information signal (orange path) in the circuit. The time period for which switch S4 (purple box) is open/closed is determined by LO_I- (orange box). Specifically, LO_I- (orange box) enables (i.e., closes) switch S4 (purple box) during an aperture thereof. An aperture describes the pulse width of the control signal (i.e., the length of activation within the signal) when the switch is closed. The diagram below represents an exemplary waveform of control signal LO_I-.



When switch S4 (purple box) is ON (closed), current can pass through the switch S4; when the switch is OFF (opened), current is blocked from passing through the switch. The switch S4 is turned ON (closed) by sending control signal LO_I- to the switch at an independent control input. The switch is kept ON (kept closed) for the duration of the signal pulse (i.e., during a sampling aperture of the pulse). Successive pulses of LO_I- (orange box) therefore recursively close/open switch S4 (purple box). The recursive closing/opening of switch S4 (purple box) periodically couples the inverted RF information signal (orange path) to a second capacitor C2 (green box). During an aperture of LO_I- (orange box), for example, switch S4 (purple box) closes and energy from inverted RF information signal (orange path) is directed to capacitor C2 (green box) along the yellow path.

(4) controlling a charging and discharging cycle of the first and second capacitors with first and second switching devices electrically coupled to the first and second capacitors, respectively; and	Each TI Chip controls a charging and discharging cycle of the first and second capacitors (e.g., capacitors C1 and C2, respectively) with first and second switching devices (e.g., switches S1 and S4, respectively) electrically coupled to the first and second capacitors, respectively. As explained above, the recursive closing/opening of the switch S1 (purple box) periodically couples the RF information signal (red path) to a first capacitor C1 (green box) according to control signal LO_I+ (orange box). During a sampling aperture of control signal LO_I+, for example, switch S1 closes and energy from the RF information signal is directed to capacitor C1 along the purple path. Between each sampling aperture of LO_I+, switch S1 remains open (i.e., RF information signal is prevented from passing through the switch). Accordingly, capacitor C1 discharges a portion of the transferred energy to a load (e.g., feedback resistor(s), yellow box shown above). Likewise, the recursive closing/opening of the switch S4 (purple box) periodically couples the inverted RF information signal (orange path) to a second capacitor C2 (green box) according to control signal LO_I- (orange box). During a sampling aperture of control signal LO_I-, for example, switch S4 closes and energy from the inverted RF information signal is directed to capacitor C2 along the yellow path. Between each sampling aperture of LO_I-, switch S4 remains open (i.e., inverted RF information signal is prevented from passing through the switch). Accordingly, capacitor C2 discharges a portion of the transferred energy to a load (e.g., feedback resistor(s), yellow box shown above).
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Stored Energy

The power delivered to a circuit element is the product of the current and the voltage (provided that the references have the passive configuration):

$$p(t) = v(t)i(t) \quad (3.9)$$

Using Equation 3.3 to substitute for the current, we have

$$p(t) = Cv \frac{dv}{dt} \quad (3.10)$$

Suppose we have a capacitor that initially has $v(t_0) = 0$. Then the initial stored electrical energy is zero, and we say that the capacitor is uncharged. Furthermore, suppose that between time t_0 and some later time t the voltage changes from 0 to $v(t)$ volts. As the voltage magnitude increases, energy is delivered to the capacitor, where it is stored in the electric field between the plates.

If we integrate the power delivered from t_0 to t , we find the energy delivered:

$$w(t) = \int_{t_0}^t p(t) dt \quad (3.11)$$

Using Equation 3.10 to substitute for power, we find that

$$w(t) = \int_{t_0}^t Cv \frac{dv}{dt} dt \quad (3.12)$$

Canceling differential time and changing the limits to the corresponding voltages, we have

$$w(t) = \int_0^{v(t)} Cv dv \quad (3.13)$$

Integrating and evaluating, we get

$$w(t) = \frac{1}{2} Cv^2(t) \quad (3.14)$$

This represents energy stored in the capacitance that can be returned to the circuit.

See Hambley, *Electrical Engineering Principles and Applications*, 6th Ed., Prentice Hall, 2014, p. 129 -130.

the RF information signal (red path) to a first capacitor C1 (green box) according to control signal LO_I+ (orange box). During a sampling aperture of control signal LO_I+, switch S1 closes and energy from the RF information signal is directed to capacitor C1 along the purple path. Between each sampling aperture of LO_I+, switch S1 remains open (i.e., RF information signal is prevented from passing through the switch). Accordingly, capacitor C1 discharges a portion of the transferred energy to a first impedance device (e.g., feedback resistor(s), yellow box), thereby generating a down-converted information signal (pink arrow) across the first impedance device.

Alternatively, in addition to, or instead of the load circuitry shown above, the load includes the load circuitry shown in the brown box below.

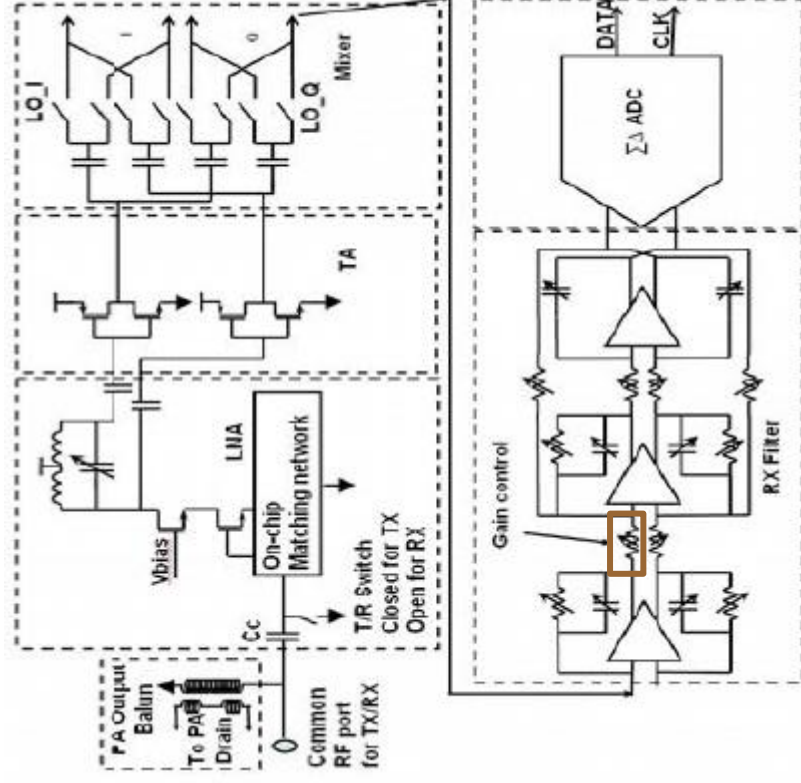


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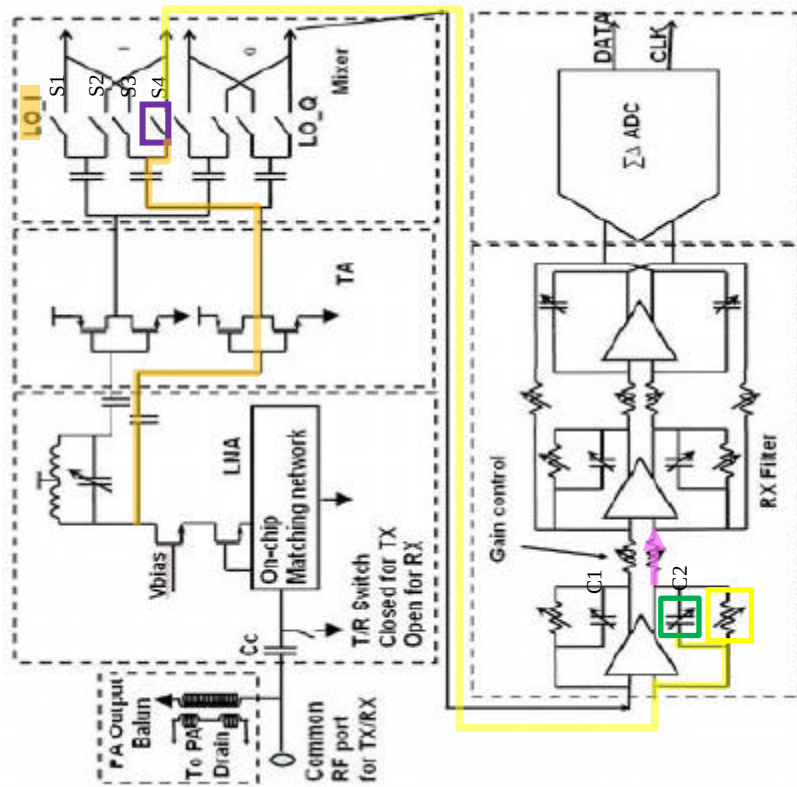


Figure 19.1.4 of 2013 IEEE paper.

Likewise, as shown above, switch S4 (purple box) includes transistors that operate as a switch with switching frequency and duty cycles controlled by LO_I- (represented by LO_I in the orange box). Control signal LO_I- (orange box) enables (i.e., closes) switch S4 during an aperture thereof. Successive pulses of LO_I- (orange box) therefore recursively close/open switch S4 (purple box). The recursive closing/opening of the switch S4 (purple box) periodically couples the inverted RF information signal (orange path) to a second capacitor C2 (green box) according to control signal LO_I- (orange box). During a sampling aperture of control signal LO_I-, switch S4 closes and energy from the inverted RF information signal is directed to capacitor C2 along the yellow path. Between each sampling aperture of LO_I-, switch S4 remains open (i.e., inverted RF information signal is prevented from passing through the

switch). Accordingly, capacitor C2 discharges a portion of the transferred energy to a second impedance device (e.g., feedback resistor(s), yellow box), thereby generating a down-converted information signal (pink arrow) across the second impedance device.

Alternatively, in addition to, or instead of the load circuitry shown above, the load includes the load circuitry shown in the brown box below.

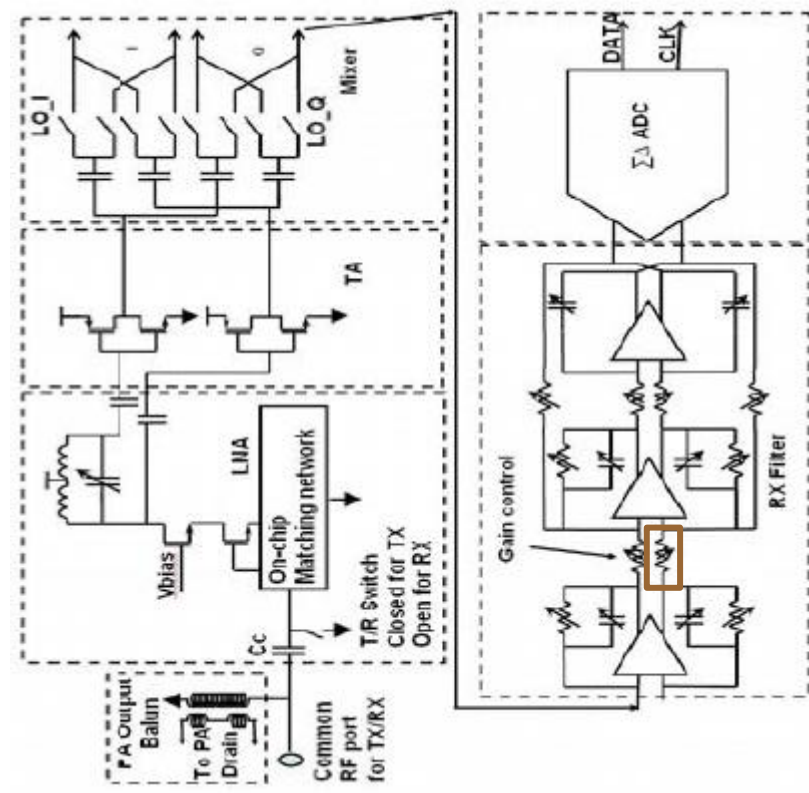


Figure 19.1.4 of 2013 IEEE paper.

wherein the information signal is used to store a charge on the first capacitor when the first switching device is closed and the inverted information signal is used to store a charge on the second capacitor when the second switching device is closed.	Each TI Chip performs a method for down-converting an electromagnetic signal wherein the information signal (e.g., RF information signal) is used to store a charge on the first capacitor (e.g., capacitor C1) when the first switching device (e.g., switch S1) is closed and the inverted information signal (e.g., inverted RF information signal) is used to store a charge on the second capacitor (e.g., capacitor C2) when the second switching device (e.g., switch S4) is closed. As explained above, the recursive closing/opening of the switch S1 (purple box) periodically couples the RF information signal (red path) to a capacitor C1 (green box) according to control signal LO_I+ (orange box). During a sampling aperture of control signal LO_I+, switch S1 closes and energy from the RF information signal is directed to capacitor C1 along the purple path. Between each sampling aperture of LO_I+, switch S1 remains open (i.e., RF information signal is prevented from passing through the switch). Accordingly, energy from the RF information signal is used to store charge on the first capacitor (e.g., capacitor C1) when the first switching device (e.g., switch S1) is closed. Likewise, the recursive closing/opening of the switch S4 (purple box) periodically couples the inverted RF information signal (orange path) to a capacitor C2 (green box) according to control signal LO_I- (orange box). During a sampling aperture of control signal LO_I-, switch S4 closes and energy from the inverted RF information signal is directed to capacitor C2 along the yellow path. Between each sampling aperture of LO_I-, switch S4 remains open (i.e., inverted RF information signal is prevented from passing through the switch). Accordingly, energy from the inverted RF information signal is used to store charge on the second capacitor (e.g., capacitor C2) when the second switching device (e.g., switch S4) is closed.
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Claim 19	TI Chips
The method of claim 18, wherein the first capacitor discharges between six percent to fifty percent of the total charge stored therein during a period of time that the first switching device is open, and wherein the second capacitor discharges between six percent to fifty percent of the total charge stored therein during a period of time that the second switching device is open.	On information and belief, each TI Chip performs a method wherein the first capacitor (e.g., capacitor C1) discharges between six percent to fifty percent of the total charge stored therein during a period of time that the first switching device (e.g., switch S1) is open, and wherein the second capacitor (e.g., capacitor C2) discharges between six percent to fifty percent of the total charge stored therein during a period of time that the second switching device (e.g., switch S4) is open. For example, and as noted above, the recursive closing/opening of switch S1 prompts a charge and discharge of the first capacitor (e.g., capacitor C1). The discharge of energy when switch S1 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 6 and 50% of the energy transferred from the RF information signal to capacitor C1 is discharged from capacitor C1 during a discharging part of the cycle (e.g., during a period of time when switch S1 is open). Likewise, the recursive closing/opening of switch S4 prompts a charge and discharge of the second capacitor (e.g., capacitor C2). The discharge of energy when switch S4 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 6 and 50% of the energy transferred from the inverted RF information signal to capacitor C2 is discharged from capacitor C2 during a discharging part of the cycle (e.g., during a period of time when switch S4 is open).
Claim 20	TI Chips
The method of claim 18, wherein the first capacitor discharges between ten percent to twenty-five percent of the total charge stored therein during a period of time that the first switching device is open, and wherein the second capacitor discharges	On information and belief, each TI Chip performs a method wherein the first capacitor (e.g., capacitor C1) discharges between ten percent to twenty-five percent of the total charge stored therein during a period of time that the first switching device (e.g., switch S1) is open, and wherein the second capacitor (e.g., capacitor C2) discharges between ten percent to twenty-five percent of the total charge stored therein during a period of time that the second switching device (e.g., switch S4) is open. For example, and as noted above, the recursive closing/opening of switch S1 prompts a charge and discharge of the first capacitor (e.g., capacitor C1). The discharge of energy when switch S1 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 10 and 25% of the

between ten percent to twenty-five percent of the total charge stored therein during a period of time that the second switching device is open.	energy transferred from the RF information signal to capacitor C1 is discharged from capacitor C1 during a discharging part of the cycle (e.g., during a period of time when switch S1 is open). Likewise, the recursive closing/opening of switch S4 prompts a charge and discharge of the second capacitor (e.g., capacitor C2). The discharge of energy when switch S4 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 10 and 25% of the energy transferred from the inverted RF information signal to capacitor C2 is discharged from capacitor C2 during a discharging part of the cycle (e.g., during a period of time when switch S4 is open).
Claim 21	TI Chips
The method of claim 18, wherein the first capacitor discharges between fifteen percent to thirty percent of the total charge stored therein during a period of time that the first switching device is open, and wherein the second capacitor discharges between fifteen percent to thirty percent of the total charge stored therein during a period of time that the second switching device is open.	On information and belief, each TI Chip performs a method wherein the first capacitor (e.g., capacitor C1) discharges between fifteen percent to thirty percent of the total charge stored therein during a period of time that the first switching device (e.g., switch S1) is open, and wherein the second capacitor (e.g., capacitor C2) discharges between fifteen percent to thirty percent of the total charge stored therein during a period of time that the second switching device (e.g., switch S4) is open. For example, and as noted above, the recursive closing/opening of switch S1 prompts a charge and discharge of the first capacitor (e.g., capacitor C1). The discharge of energy when switch S1 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 15 and 30% of the energy transferred from the RF information signal to capacitor C1 is discharged from capacitor C1 during a discharging part of the cycle (e.g., during a period of time when switch S1 is open). Likewise, the recursive closing/opening of switch S4 prompts a charge and discharge of the second capacitor (e.g., capacitor C2). The discharge of energy when switch S4 is open may be obtained from the down-convert impulse response (e.g., source and load impedances, action of the switch, storage capacitances) and the final state of the cumulative prior charging/discharging cycles. On information and belief, between 15 and 30% of the energy transferred from the inverted RF information signal to capacitor C2 is discharged from capacitor C2 during a discharging part of the cycle (e.g., during a period of time when switch S4 is open).

Claim 22

The method of claim 18, further comprising the step of: amplifying the first and second down-converted information signals.

TI Chips

On information and belief, each TI Chip amplifies the first and second down-converted information signals (represented by the pink arrows) via e.g., differential amplifier circuit(s) (shown in the purple box).

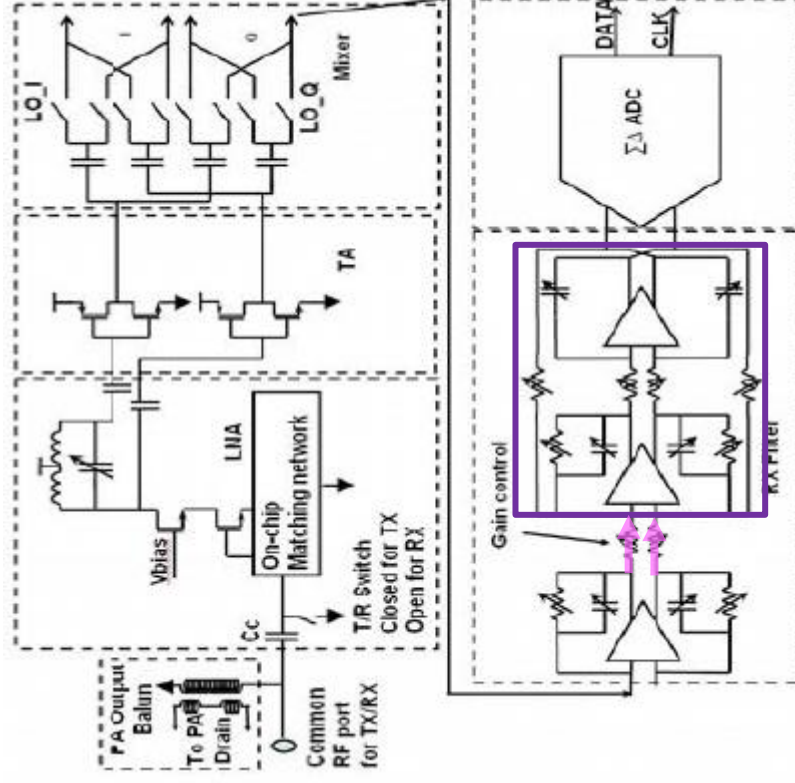


Figure 19.1.4 of 2013 IEEE paper.

Claim 23	TI Chips
The method of claim 18, further comprising the step of: removing a carrier signal from the first and second down-converted information signals.	Each TI Chip removes a carrier signal from the first and second down-converted information signals. Specifically, on information and belief, each TI Chip directly down-converts the RF information signal/inverted RF information signal to baseband signals.