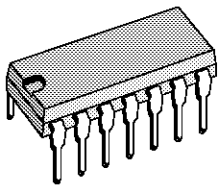
SGS-THOMSON MICROELECTRONICS

# STV4614C

## SWITCH MODE POWER SUPPLY CONTROLLER

**ADVANCE DATA**

- FLYBACK CONVERTER POWER SUPPLY
- CURRENT MODE CONTROLLED SMPS
- LOW POWER CONSUMPTION
- PRIMARY AND SECONDARY REGULATION
- CONTROL OF CONDUCTION TIME AND OF SWITCHING FREQUENCY
- REVERSE CURRENT CONCEPT
- SOFTSTART
- ADJUSTABLE OVERCURRENT DETECTOR
- SECURITY FUNCTION FOR SHORT-CIRCUIT



**DIP14**
(Plastic Package)

**ORDER CODE :** STV4614C

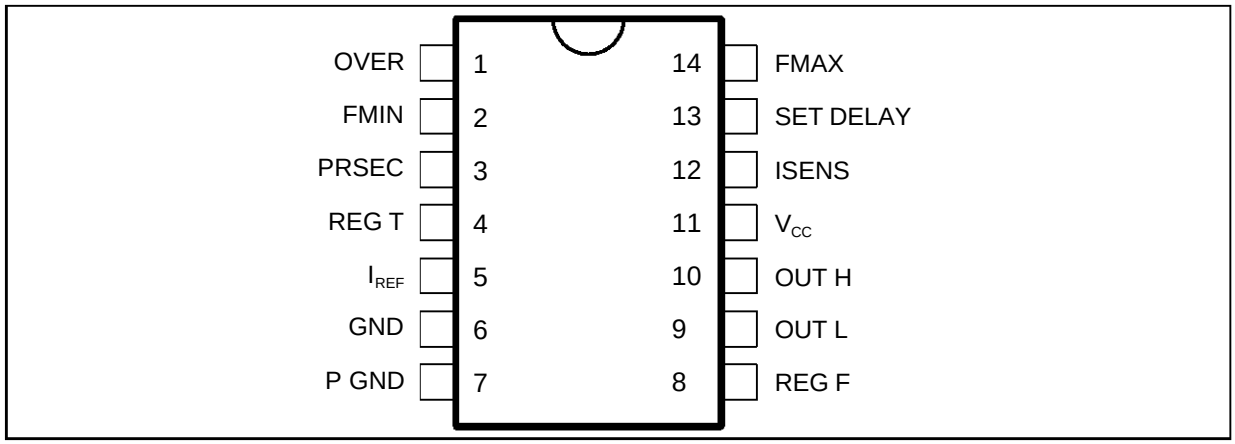
### DESCRIPTION

The STV4614C is an IC designed to drive the bipolar switching transistor in a Switch Mode Power Supply.

The STV4614C can be used in a flyback converter structure in a primary regulation or in secondary regulation with the reverse current concept.

This concept allows a secondary regulation without need of optocoupler or dedicated transformer to send a regulating signal from secondary to primary side. The regulating signal is sent through the main transformer during a dead time, after the energy have been transfered from primary to secondary side.

### PIN CONNECTIONS



## PIN DESCRIPTION

| Pin N° | Symbol | Description |
|---|---|---|
| 1 | OVER | Threshold for OVERLOAD at Pin ISENS. |
| 2 | FMIN | An external resistor on this pin fixes the minimum switch frequency, reached for min load. |
| 3 | PRESEC | Input for the primary and secondary regulation information. |
| 4 | REG T | Output of the transconductance error amplifier which is internal by connected to the input of the PWM generator. The external RC network is responsible for the accuracy, dynamic and stability of the regulation loop. |
| 5 | $I_{REF}$ | External resistor generating a temperature independent internal current. |
| 6 | GND | Ground. |
| 7 | P GND | Power ground internally connected to the power elements. |
| 8 | REG F | Input of the frequency regulation. The information of the Pin REG T is transferred through a RC network to Pin REG F. This external RC network is responsible for the range and stability of the frequency regulation. |
| 9 | OUT L | The current at this pin has the task to collect quickly the charge carriers in the base region of the saturated switch transistor. |
| 10 | OUT H | The current at this pin is the base current of the switch transistor. |
| 11 | $V_{CC}$ | Positive power supply. |
| 12 | ISENS | Detection of the collector current of the switch transistor to control the conduction time. To avoid damage from the IC and the application, this pin delivers a current of 200mA if the voltage becomes lower than -9.1V (security function). |
| 13 | SET DELAY | Time delay for the detection of the secondary regulation information. |
| 14 | FMAX | The threshold voltage at FMAX adjusts the output power at which the maximum frequency is reached. |

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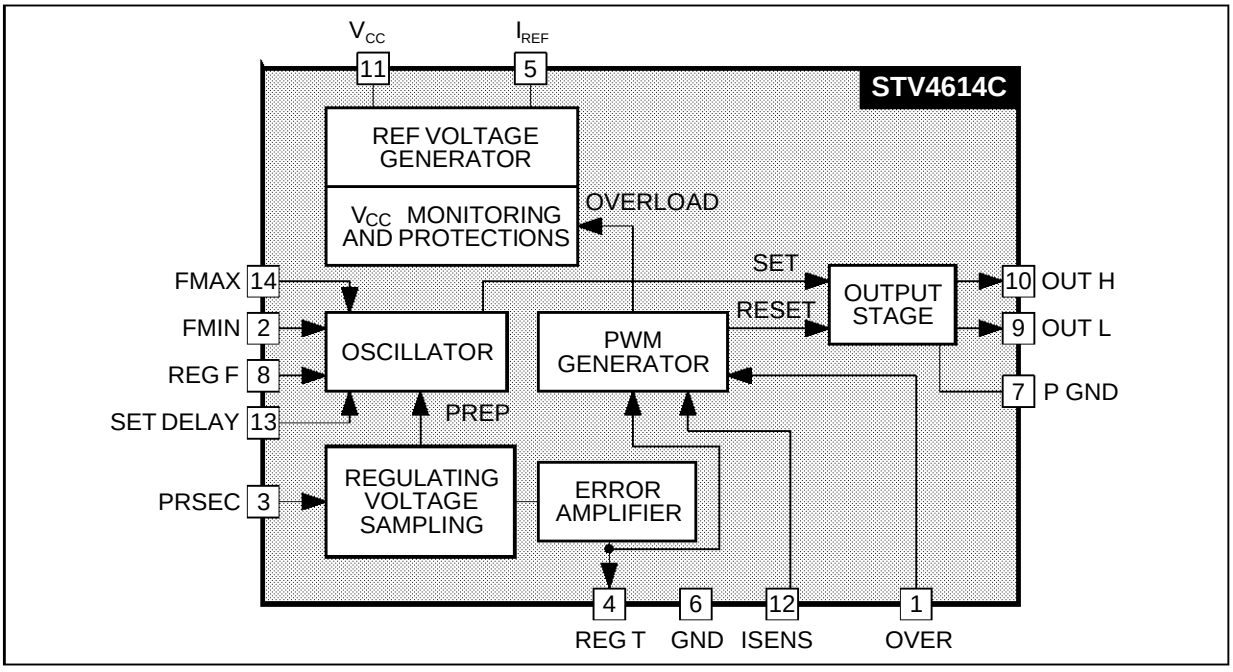
## BLOCK DIAGRAM

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## CIRCUIT DESCRIPTION

In free running flyback-converters, the STV4614C assumes the control of the bipolar switching transistor and all necessary regulations and monitoring functions.

It consists of seven blocks (see block diagram).

### The DC Reference Generator

This blocks generates a reference voltage (Pin $I_{REF}$). Via an external resistor (15kΩ) a temperature independent current is generated.

### The $V_{CC}$ Monitoring and Protection Block

By monitoring the $V_{CC}$ voltage, the IC determines the mode in which the circuit is working.

Five phases are monitored : start-up, initialisation, softstart, normal mode and switch off.

Also this block identifies dangerous operation conditions. E. g. if $V_{CC}$ is too low, the IC switches off ($V_{IREF}$ goes to zero).

### The Sampling Block

This block detects the regulation information coming from a winding of the transformer and generates the sample voltage.

The IC can operate in primary or secondary regulation. By using the secondary regulation, the secondary information ($V_{SEC}$) has to be larger than the primary information ($V_{PR}$). Otherwise the SMPS is in primary regulation. This relation is fixed by external elements at Pin PRSEC.

The primary regulation information is sampled during the conduction time of the secondary diodes (secondary conduction time).

The secondary regulation information is included in the amplitude of the first ringing after the secondary conduction time. The amplitude of this ringing is processed by a circuit on the secondary side (”reverse current”). If a failure of the secondary regulation loop occurs, the IC takes over the primary regulation to limit the output voltages.

The sampling block identifies the end of the secondary conduction time. Then it generates a PREP signal for the oscillator block.

The PREP pulse is generated if following condition is valid :

$Tx \times V_{SEC} \geq 2.10^{-7}$ (Volts.Second) (see Figure 1)

Otherwise the PREP pulse is forced after a specified time.

### The Error Amplifier

This block transforms the sample voltage into the regulation voltage (REG T, REG F). See Figures 5 and 6.

The REGT voltage determines the conduction time of the switching transistor. This REG T voltage is transmitted by an external RC network to the pin REG F, which is responsible for the switching frequency.

In case of overload or underload, the IC switches off. In normal mode, the REG T voltage is proportional to the output power.

### The Oscillator

This block generates a SET signal which starts the conduction of the switching transistor. The voltages at REG F, FMAX and SET DELAY and the current generated by the resistor at FMIN determine the time $T_R$ between the PREP pulse and the SET pulse (see normal mode).

### The PWM Generator Block

This block detects the collector current of the switching transistor at pin ISENS and generates a RESET signal if this current exceeds the allowed maximum current which is proportional to the REGT voltage. This RESET starts the switch off of the switching transistor.

This block contains some safety functions : if the collector current rises too fast, OVERLOAD is activated. In case of fatal error (ISENS voltage < -9V) ISENS delivers a current which destroyes an external fuse resistor to prevent further damage from the SMPS.

### The Output Stage

This block drives the switching transistor. It has two seperate outputs : OUT H for the conducting time and OUT L for an active switch off (collection of base charge carriers).

## FUNCTIONAL DESCRIPTION

### Startup Phase

Mains charges an external capacitor at Pin $V_{CC}$. No current is consumed by the IC.

**Initialisation Phase** (see Figure 2)

If $V_{CC}$ exceeds $V_{INITON}$ the IC starts the initialisation. When $V_{CC}$ reaches $V_{ON}$, the IC switches on. The reference voltage at $I_{REF}$ is then 3.5V. The current consumption exceeds the current which is delivered by the mains. This current must be delivered from the $V_{CC}$ capacitor. As a result the $V_{CC}$ voltage decreases. This initialisation ends when the $V_{CC}$ voltage decreases below the $V_{ENDIN}$ voltage. Note : during the initialisation phase no output pulses are generated.

### Softstart

When the $V_{CC}$ voltage is lower than $V_{ENDIN}$ voltage, the IC delivers pulses to drive the switching transistor. The power transmission is increased slowly. The velocity of the softstart is fixed internally.

The stored energy in the $V_{CC}$ capacitor supplies the IC during softstart. Afterwards the IC is supplied by a transformer winding.

### Normal Mode Phase

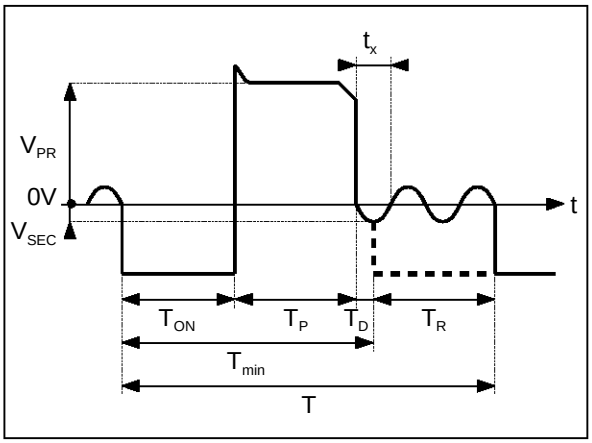
If the output voltages of the SMPS have reached their nominal values, the IC enters the normal mode operation.

#### *Timing diagram*

A typical waveform of PRSEC signal is shown in Figure 1. The cycle time T consists of four parts :

- $T_{ON}$ time ($V_{PRSEC}$ low) : the switching transistor is on and the current flows into the transformer.
- $T_P$ time ($V_{PRSEC}$ high) : the switching transistor is off and the current flows out of the transformer through the secondary diodes.
- $T_D$ time ($V_{PRSEC}$ around zero) : the transformer is free oscillating. This time includes a fixed time delay and an adjustable delay (Pin SET DELAY). This $T_D$ time defines the earliest start of a new cycle. This ensures an energy free transformer and a proper detection of the secondary regulation information.
- $T_R$ time (still free oscillating of the transformer) : this time results of the frequency regulation. Its value is defined by the following formula :
  $T_R = 5.10^{-4} \times R_{FMIN} \times (V_{FMAX} + 0.7V - V_{REGF})$
  with $T_R$ in µs, $R_{FMIN}$ in Ω and V in Volt.
  This equation is only valid for $V_{REGF} > 0.9V$ and $T_R > 0$. Otherwise $T_R = 0$.

**Figure 1 :** $V_{PRSEC}$ Voltage Waveform




#### *Frequency and $T_{ON}$ Regulation*

At low load the switching frequency and $T_{ON}$ is proportional to the output power. If REG T and REG F voltage is equal to the voltage of $V_{FMAX}$ + 0.7V, the switching frequency is maximum. The further increase of output power ($V_{REG\ T}$, $V_{REG\ F}$ larger than $V_{FMAX}$ + 0.7V) is reached by only increasing the conduction time which reduces slightly the frequency. In this mode losses in snubber network and switching transistors are low.

The secondary information is manipulated by a circuit on the secondary side. This circuit compares the output voltage with a reference voltage and transmits a "reverse current" during the free oscillating time from the secondary to the primary side of the transformer. This "reverse current" manipulates the amplitude of the ringing, which can be sampled at the PRSEC input.

**Switch Off** (see Figure 3)

If the $V_{CC}$ voltage falls under $V_{OFF}$ or another OVERLOAD function is triggered the voltage reference ($I_{REF}$) and the external switch transistor are switched off. An internal current source is switched on, which discharge the external $V_{CC}$ capacitor below $V_{LOW}$ to ensure a new startup. Therefore the supply current delivered by the mains must be lower than this internal current ($I_{LOWOFF}$).

If $V_{CC}$ voltage reaches $V_{LOW}$, the internal current is switched off (no current consumption) and a new startup begins.

This is a safety feature which ensures in case of failure, that the power parts cannot be overloaded, because they are off for a long time (during switch off and startup).

## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply Voltage | 20 | V |
| $T_j$ | Junction Temperature | 125 | °C |
| $T_{stg}$ | Storage Temperature | -40, +150 | °C |
| $T_{oper}$ | Operating Temperature | 0, +70 | °C |

4614C-02.TBL

## NORMAL OPERATING CONDITIONS

| Pin N° | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| 1 | OVER | 0 | | 3.65 | V |
| 2 | FMIN | 2.65 | | 2.95 | V |
| 3 | PRSEC | -4.5 | | 4.5 | V |
| 4 | REG T | 0.7 | | 4.25 | V |
| 8 | REG F | 0.7 | | 4.25 | V |
| 9 | OUT L | 0 | | 8 | V |
| 10 | OUT H | -5 | | 8 | V |
| 11 | $V_{CC}$ | 6.3 | 9 | 17.5 | V |
| 12 | ISENS | -11 | | 0 | V |
| 13 | SET DELAY | 0.5 | | 3 | V |
| 14 | FMAX | 0 | | 3.65 | V |
| 4 | $I_{REGT}$ | | ±100 | | µA |
| 3 | $T_{PRSEC}$ : Pulse Duration for Reading the Primary or Secondary Information. | 500 | | | ns |
| 10 | Minimal SET Reaction Time ($V_{SET\ DELAY}$ = 0.5V) | | | 900 | ns |

4614C-06.TBL

## THERMAL DATA

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{th(j-a)}$ | Junction Ambient Thermal Resistance | 90 | °C/W |

4614C-03.TBL

## ELECTRICAL CHARACTERISTICS ($T_{amb}$ = 25°C)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| PROTECTION | | | | | | |
| VPISENS | Protection Current | If the voltage at Pin ISENS is VPISENS, a 100mA current flows out of Pin ISENS | -11 | -10 | -8 | V |
| IISENS | Protection Current | Maximum current flowing out the Pin ISENS | 200 | | | mA |
| OVER | Voltage at Pin ISENS | IC switchs off (OVERLOAD) because ISENS voltage reaches threshold, fixed by OVER voltage | -3.0 | | -0.5 | V |
| DC CHARACTERISTICS | | | | | | |
| $V_{CC}$ Characteristics in Switch On Phase (Soft Start) and in Normal Mode (Figure 2) | | | | | | |
| $I_{REF}$ | Reference Voltage | Bandgap is activated | 3.35 | 3.5 | 3.65 | V |
| $V_{INIT/ON}$ | $V_{CC}$ Voltage | | 15 | | 17 | V |
| $I_{INIT/ON}$ | $I_{CC}$ Current | | | | 700 | µA |
| $V_{ON}$ | $V_{CC}$ Voltage | If $V_{CC}$ exceeds $V_{ON}$ the bandgap is activated | 15.5 | 16.5 | 17.5 | V |
| $I_{ON}$ | Current Consumption | Startup mode : $V_{CC} > V_{INIT}$ : bandgap on | 13 | 21.5 | 28 | mA |
| $V_{ENDIN}$ | $V_{CC}$ Voltage | End of initialization (normal mode) : $V_{CC} < V_{ENDIN}$ | 15 | | 17 | V |
| $I_{ENDIN}$ | Current Consumption | End of initialisation : $V_{CC} < V_{ENDIN}$ | 4 | | 10 | mA |
| P | Power Consumption | Period time T = 7µs, $T_{ON}$ = 3µs<br>Base discharge time $T_B$ = 1µs | | | 0.6 | W |
| $V_{CC}$ Characteristics in Switch Off Phase (Figure 3)<br>If $V_{CC}$ becomes lower than $V_{OFF}$ the reference voltage ($I_{REF}$) is switched off and an internal current source $I_{LOWOFF}$ is switched on.<br>If $V_{CC}$ becomes lower than $V_{LOW}$, the internal current source $I_{LOWOFF}$ is switched off. A new startup can begin. | | | | | | |
| $V_{OFF}$ | $V_{CC}$ Voltage | $V_{CC} < V_{OFF}$ : voltage reference is switched off | 6.3 | 6.7 | 7.1 | V |
| $I_{LOWOFF}$ | Current Consumption | $V_{LOW} < V_{CC} < V_{OFF}$ | 6 | | 11 | mA |
| $V_{LOW}$ | $V_{CC}$ Voltage | $V_{CC} < V_{LOW}$ : the whole IC is switched off | 2.5 | 3 | 4 | V |
| $DV_{ONOF}$ | $V_{CC}$ Range in Normal Mode | $DV_{ONOF} = V_{ON} - V_{OFF}$.<br>Tested under application conditions. | 8.8 | 9.5 | | V |

4614C-04.TBL

**Figure 2 :** IC from OFF to ON and Normal Mode

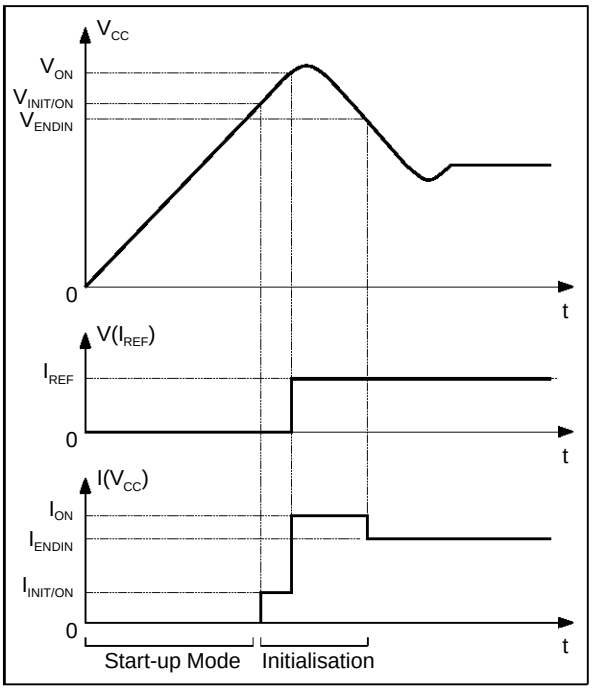



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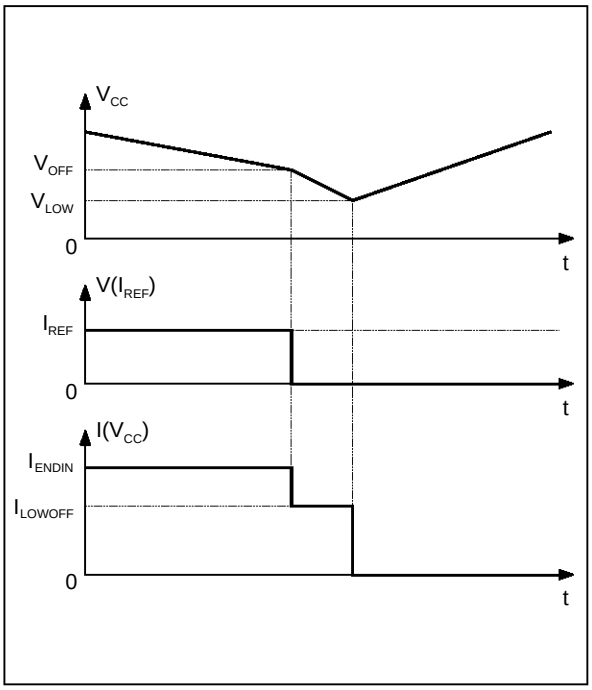
**Figure 3 :** IC from ON to OFF

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**ELECTRICAL CHARACTERISTICS** (continued) ($T_{amb}$ = 25°C)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| PERIODIC FUNCTIONS - OUTPUT CHARACTERISTICS (Figure 4) ($V_{CC}$ = 9V, $V_{OVER}$ = 3V, $V_{REGT}$ = $V_{REGF}$ = 3V, $V_{FMAX}$ = 1V, $V_{SET\ DELAY}$ = 0.5V, $I_{OUTH}$ = 200mA, $I_{OUTL}$ = 200mA, $R_{FMIN}$ = 18kΩ) | | | | | | |
| $V_{DROPH}$ | Voltage Drop at OUT H | $I_{OUTH}$ = 200mA | | 1.8 | 2.2 | V |
| $I_{OUTH}$ | Output H Current | | | | +200 | mA |
| $V_{DROPL}$ | Voltage Drop at OUT L | $I_{OUTL}$ = -800mA | | 1.5 | 2.3 | V |
| $I_{OUTL}$ | Output L Current | | -800 | | +200 | mA |
| $R_{OUTH}$ | Rising Time of OUT H Signal | | | | 150 | ns |
| $F_{OUTH}$ | Falling Time of OUT H Signal | | | | 150 | ns |
| $R_{OUTL}$ | Rising Time of OUT L Signal | | | | 200 | ns |
| $F_{OUTL}$ | Falling Time of OUT L Signal | | | | 200 | ns |
| $T_{DHL}$ | Time Delay Between the Falling Times of OUT H and OUT L | | 90 | | 150 | ns |
| $V_{zen}$ | Maximum Voltage on Pins OUT H and OUT L | $V_{CC}$ = 10V to 13V | 6.9 | 7.4 | 8 | V |
| $T_{SET}$ | Forced SET Time | | 24 | 31 | 43 | µs |
| $T_{SETMAX}$ | Maximum SET Delay | $V_{SET\ DELAY}$ = 3V | | 1.3 | | µs |
| $F_{MINAB}$ | Δ(1/Fmin) | For R = 10kΩ (Ra) and R = 18kΩ (Rc) | | 9 | | µs |
| $F_{MINBC}$ | Δ(1/Fmin) | For R = 18kΩ (Rb) and R = 33kΩ (Rc) | | 16 | | µs |
| $\Delta F_{MAX}$ | Δ(1/Fmax) | | | 14 | | µs |
| $M_{INCT}$ | Minimal Conduction Time | | 350 | 450 | 600 | ns |
| Control Characteristics for Primary Regulation (Figure 5) | | | | | | |
| $\Delta V_{REG1}$ | $\Delta V_{REG}$ | At $V_{PR}$ = 0.5V and 2.5V | 1.9 | 1.96 | 2.1 | V |
| $V_{REGPR1}$ | $V_{REG}$ in Primary Regulation | At $V_{PR}$ = 3V | 3.9 | 4.1 | 4.3 | V |
| $\Delta V_{REG2}$ | $\Delta V_{REG}$ | At $V_{PR}$ = 3.3V and 3.6V | 1.1 | 1.35 | 1.6 | V |
| $V_{PROFF}$ | $V_{PR}$ which Switches the IC Off | | 4.5 | | | V |
| Control Characteristics for Secondary Regulation (Figure 6) | | | | | | |
| $\Delta V_{RS1}$ | $\Delta V_{REG}$ | At VSEC = -1.2V and -2.5V | 1.1 | 1.32 | 1.5 | V |
| $V_{RS28}$ | $V_{REG}$ | At VSEC = -2.8V | 3.75 | 4 | 4.25 | V |
| $\Delta V_{RS2}$ | $\Delta V_{REG}$ | At $V_{SEC}$ = -3.2V and -3.5V | | 1.25 | | V |
| $V_{SECOFF}$ | $V_{SEC}$ which Switches the IC Off | | | | -4.5 | V |

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**Figure 4**

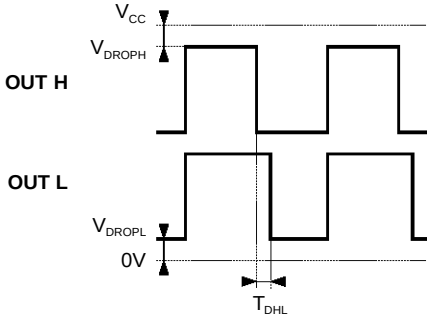


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**Figure 5**

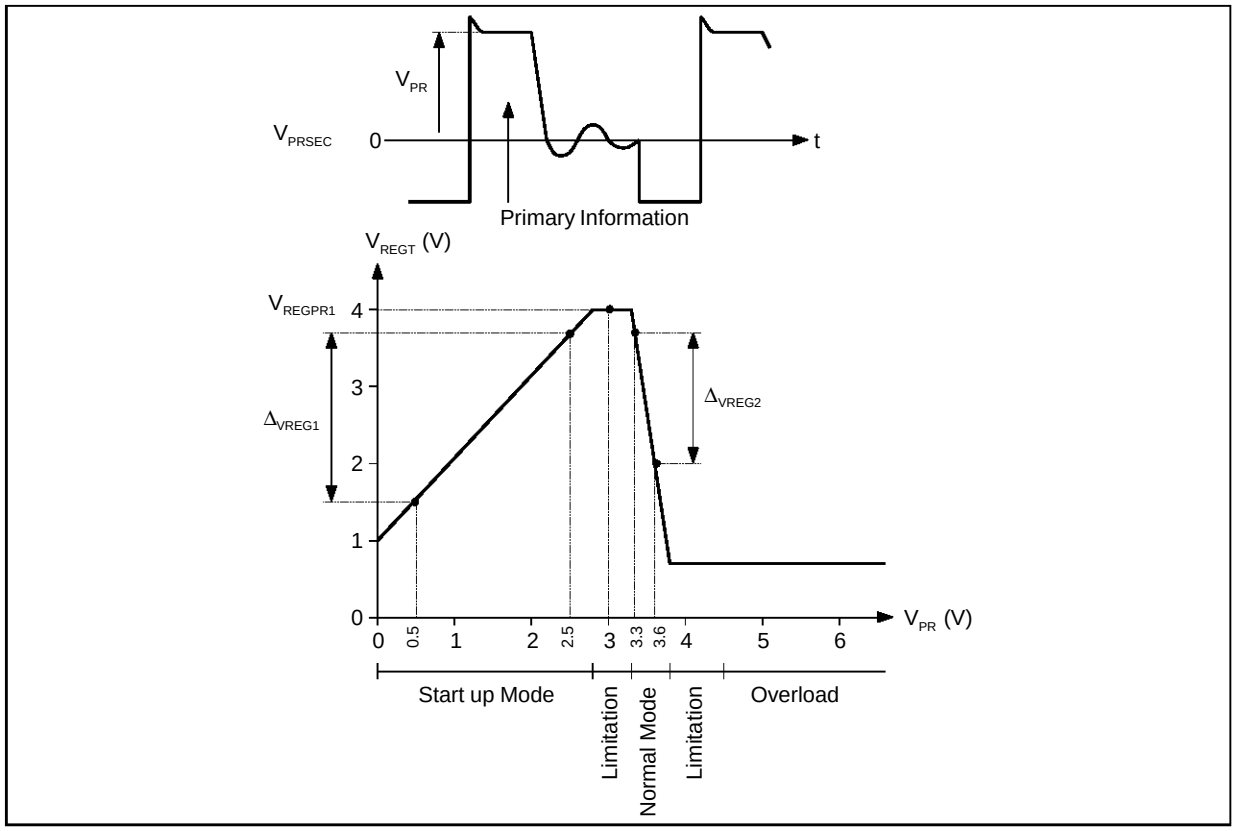
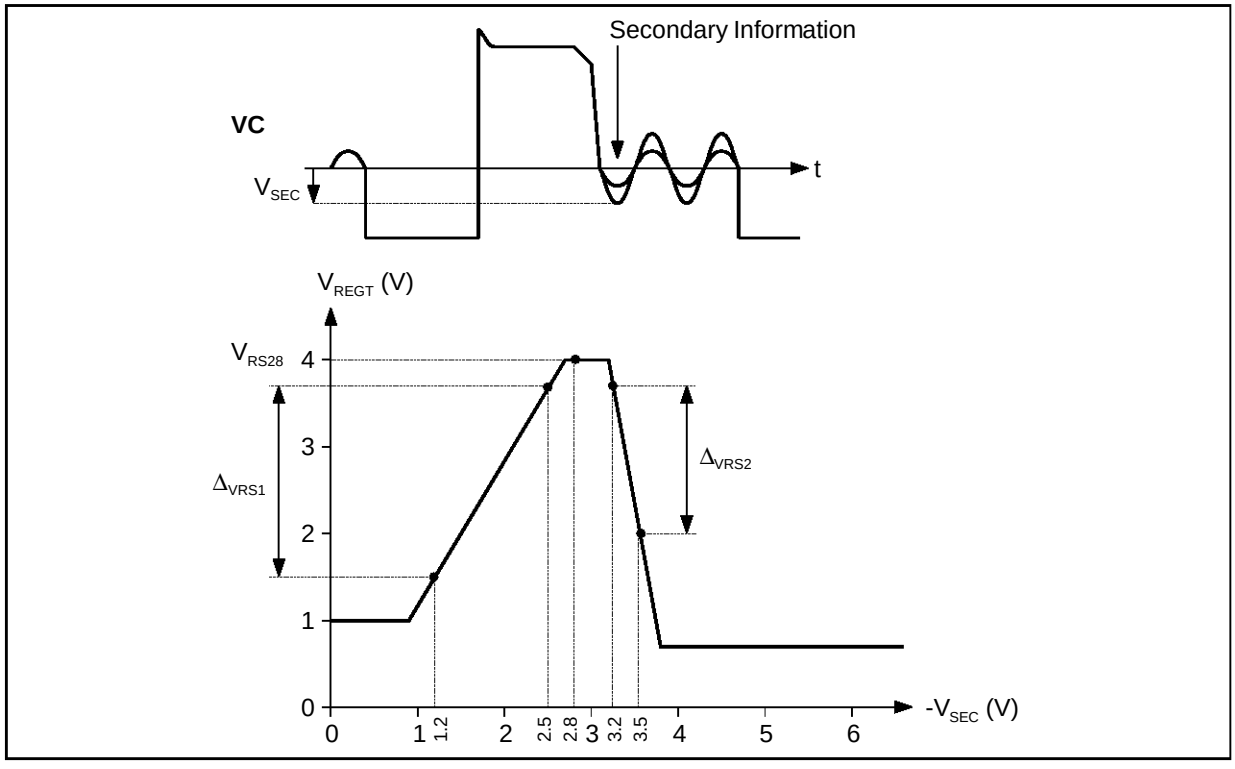


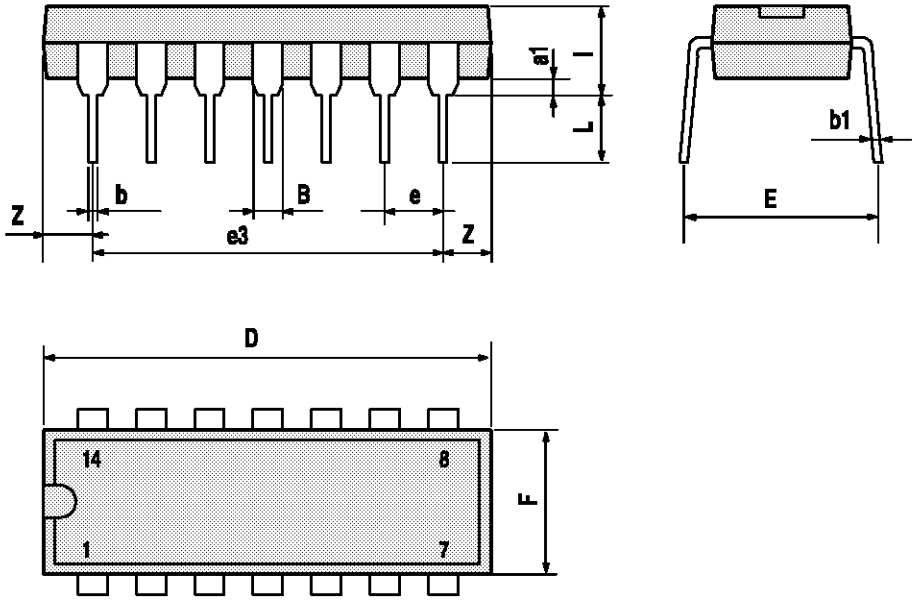

**Figure 6**



## APPLICATION DIAGRAM

## PACKAGE MECHANICAL DATA

14 PINS - PLASTIC PACKAGE

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| Dimensions | Millimeters | | | Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| a1 | 0.51 | | | 0.020 | | |
| B | 1.39 | | 1.65 | 0.055 | | 0.065 |
| b | | 0.5 | | | 0.020 | |
| b1 | | 0.25 | | | 0.010 | |
| D | | | 20 | | | 0.787 |
| E | | 8.5 | | | 0.335 | |
| e | | 2.54 | | | 0.100 | |
| e3 | | 15.24 | | | 0.600 | |
| F | | | 7.1 | | | 0.280 |
| i | | | 5.1 | | | 0.201 |
| L | | 3.3 | | | 0.130 | |
| Z | 1.27 | | 2.54 | 0.050 | | 0.100 |

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