

The SP5054 is a single-chip frequency synthesiser designed for satellite TV tuning systems. It is a programming variant of the SP5055, allowing the design of one tuner with either I<sup>2</sup>C bus or 3-wire bus format, depending on which device is inserted. The SP5054, when used with a satellite varactor tuner, forms a complete phase locked loop tuning system.

The circuit consists of a divide-by-16 prescaler with its own preamplifier and a 14/15-bit programmable divider controlled by a serially-loaded data register. Four independently programmable open-collector outputs are included. The device has four modes of operation, selected by the Mode Select input; these modes are summarised in Table 1.

The comparison frequencies are obtained by the division of the output of a 4MHz crystal controlled on-chip oscillator. The phase comparator has a charge pump output with an output amplifier stage around which feedback may be applied. Only one external transistor is required for varactor line driving.

### FEATURES

- Complete 2.6GHz Single Chip System
- 62.5kHz, 100kHz and 125kHz Step Size
- Low Power Consumption (325mW Typ.)
- Programming Compatible with Toshiba TD6380, TD6381 and TD6382 \*
- Pin Compatible with SP5055 \*
- Low Radiation
- Varactor Drive Amplifier Disable
- Charge Pump Disable
- Single Port 18/19 Bit Serial Data Entry
- Four Controllable Outputs
- ESD Protection †

\* See notes on pin compatibility

† Normal ESD handling precautions should be observed

### APPLICATIONS

- Satellite TV
- High IF Cable Tuning Systems

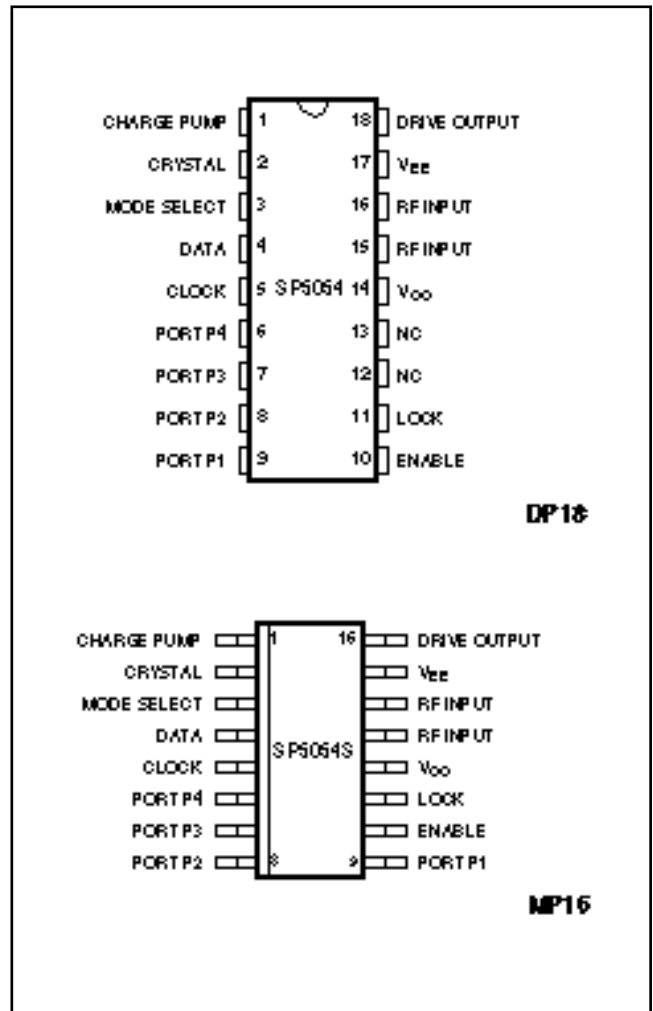


Fig. 1 Pin connections – top view

### ORDERING INFORMATION

- SP5054 KG DPAS (18-lead plastic package)
- SP5054S KG MPAS (16-lead miniature plastic package)

## SP5054

### ELECTRICAL CHARACTERISTICS

$T_{AMB} = -20^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ ,  $V_{CC} = +4.5\text{V}$  to  $+5.5\text{V}$ . Frequency standard = 4MHz. All pin connections refer to DP package. These Characteristics are guaranteed by either production test or design. They apply within the specified ambient temperature and supply voltage ranges unless otherwise stated.

| Characteristic                           | Pin    | Value |           |          | Units                   | Conditions  |
|--|--------|-------|-----------|----------|-------------------------|---|
|  |        | Min.  | Typ.      | Max.     |                         |   |
| Supply current                           | 14     |       | 65        | 80       | mA                      | $V_{CC} = 5\text{V}$<br>500MHz to 2.6GHz sinewave<br>120MHz and 500MHz, see Fig. 6  |
| Prescaler input voltage                  | 15,16  | 50    |           | 400      | mVrms                   |   |
| Prescaler input voltage                  |        | 100   |           | 400      | mVrms                   |   |
| Prescaler input impedance                | 15,16  |       | 50        |          | pF                      |   |
| Input capacitance                        |        |       | 2         |          |                         |   |
| High level input voltage                 | 4,5,10 | 3     |           | $V_{CC}$ | V                       | $V_{IN} = 5.5\text{V}$ , $V_{CC} = 5.5\text{V}$<br>$V_{IN} = 0\text{V}$ , $V_{CC} = 5.5\text{V}$<br>$V_{IN} = 0\text{V}$ , $V_{CC} = 5.5\text{V}$<br>$V_{IN} = 5.5\text{V}$ , $V_{CC} = 5.5\text{V}$<br>$V_{IN} = 0\text{V}$ , $V_{CC} = 5.5\text{V}$ |
| Low level input voltage                  | 4,5,10 | 0     |           | 0.7      | V                       |   |
| High level input current                 | 4,5,10 |       |           | 1        | $\mu\text{A}$           |   |
| Low level input current                  | 5      |       |           | 5        | $\mu\text{A}$           |   |
| Low level input current                  | 4,10   |       |           | -250     | $\mu\text{A}$           |   |
| High level input current                 | 3      |       |           | 700      | $\mu\text{A}$           |   |
| Low level input current                  | 3      |       |           | -700     | $\mu\text{A}$           |   |
| Clock inout hysteresis                   | 5      |       | 0.4       |          | V                       | See Fig. 4<br>See Fig. 4<br>See Fig. 4<br>See Fig. 4<br>See Fig. 4  |
| Clock rate                               | 5      |       |           | 0.5      | MHz                     |   |
| Data set up time, $t_2$                  | 4      | 300   |           |          | ns                      |   |
| Data hold time, $t_3$                    | 4      | 600   |           |          | ns                      |   |
| Enable set up time, $t_1$                | 10     | 300   |           |          | ns                      |   |
| Enable hold time, $t_5$                  | 10     | 600   |           |          | ns                      |   |
| Clock-to-enable time, $t_4$              | 10     | 300   |           |          | ns                      |   |
| Charge pump output current               | 1      |       | $\pm 150$ |          | $\mu\text{A}$           | V pin 1 = 2.0V<br>V pin 1 = 2.0V<br>At collector of external transistor<br>V pin 18 = 0.7V<br>I pin 18 = 100 $\mu\text{A}$  |
| Charge pump output leakage current       | 1      |       |           | $\pm 5$  | nA                      |   |
| Drift due to leakage                     |        |       |           | 5        | mV/s                    |   |
| Charge pump drive output current         | 18     | 1     |           |          | mA                      |   |
| Charge pump amplifier gain               |        |       | 6400      |          |                         |   |
| Oscillator temperature stability         |        |       |           | 2        | ppm/ $^{\circ}\text{C}$ |   |
| Oscillator stability with supply voltage |        |       |           | 2        | ppm/V                   |   |
| Recommended crystal series resistance    |        | 10    |           | 200      | mV p-p                  | Parallel resonant crystal (note 1)<br>Nominal spread = $\pm 15\%$   |
| Crystal oscillator drive level           | 2      |       | 40        |          |                         |   |
| Crystal oscillator source impedance      | 2      |       | -400      |          |                         |   |
| <b>Ports and Lock Output</b>             |        |       |           |          |                         |   |
| Sink current                             | 6-9,11 | 10    |           |          | mA                      | $V_{OUT} = 0.7\text{V}$<br>$V_{OUT} = 13.2\text{V}$   |
| Port leakage current                     | 6-9    |       |           | 10       | $\mu\text{A}$           |   |
| Varactor drive amplifier disable         | 10     | -350  |           |          | $\mu\text{A}$           | $V_{IN} < 0\text{V}$<br>$V_{IN} < 0\text{V}$  |
| Charge pump disable                      | 4      | -350  |           |          | $\mu\text{A}$           |   |

NOTE 1. The maximum resistance quoted refers to all conditions, including start-up.

**ABSOLUTE MAXIMUM RATINGS**

All voltages are referred to  $V_{EE} = 0V$

| Parameter                                | Pin    |         | Value |              | Units | Conditions            |
|--|--------|---------|-------|--------------|-------|-----------------------|
|  | SP5054 | SP5054S | Min.  | Max.         |       |                       |
| Supply voltage                           | 14     | 12      | -0.3  | 7            | V     |                       |
| RF input voltage                         | 15,16  | 13,14   |       | 2.5          | V p-p |                       |
| Port voltage                             | 6-9    | 6-9     | -0.3  | 14           | V     | Port in off state     |
|  | 6-9    | 6-9     | -0.3  | 6            | V     | Port in on state      |
| Prescaler DC offset                      | 15,16  | 13-14   | -0.3  | $V_{CC}+0.3$ | V     |                       |
| Loop amplifier DC offset                 | 1,18   | 1,16    | -0.3  | $V_{CC}+0.3$ | V     |                       |
| Crystal oscillator DC offset             | 2      | 2       | -0.3  | $V_{CC}+0.3$ | V     |                       |
| Data bus inputs                          | 4,5,10 | 4,5,10  | -0.3  | $V_{CC}+0.3$ | V     | With $V_{CC}$ applied |
| Storage temperature                      |        |         | -55   | +150         | °C    |                       |
| Junction temperature                     |        |         |       | +150         | °C    |                       |
| DP18 thermal resistance, chip-to-ambient |        |         |       | 78           | °C/W  |                       |
| DP18 thermal resistance, chip-to-case    |        |         |       | 24           | °C/W  |                       |
| MP16 thermal resistance, chip-to-ambient |        |         |       | 111          | °C/W  |                       |
| MP16 thermal resistance, chip-to-case    |        |         |       | 41           | °C/W  |                       |
| Power consumption at 5.5V                |        |         |       | 484          | mW    |                       |

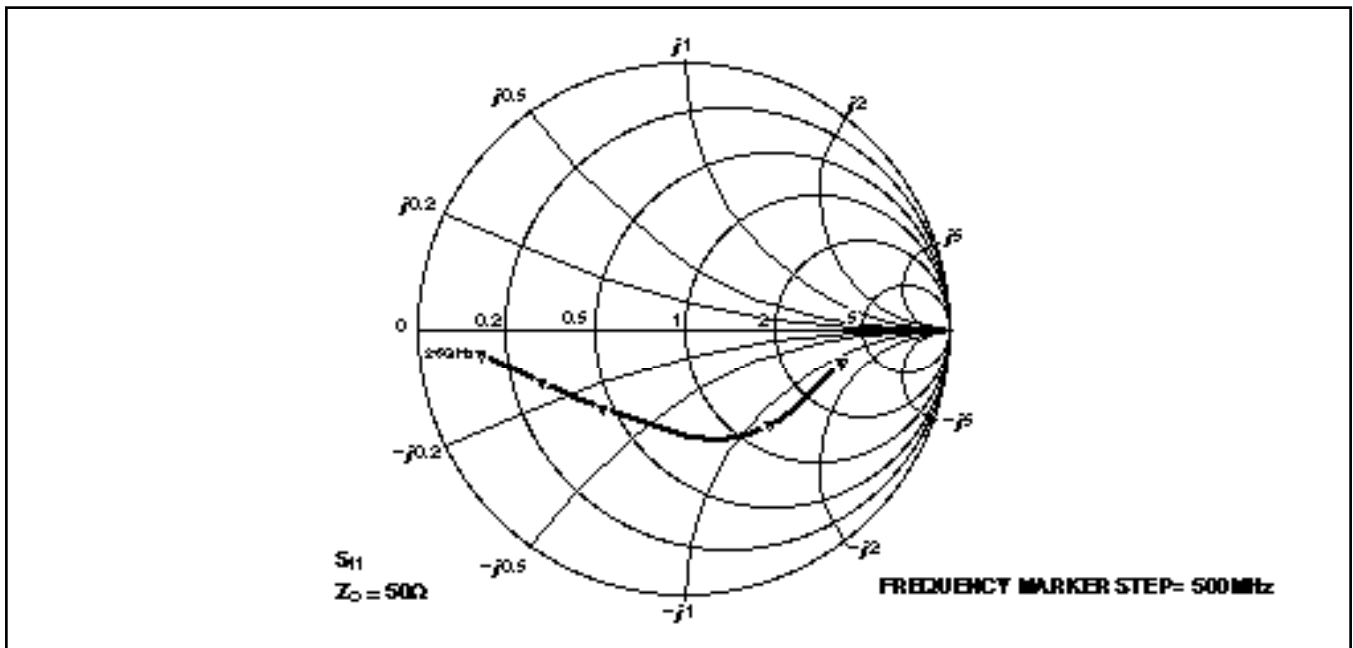


Fig. 2 Typical input impedance

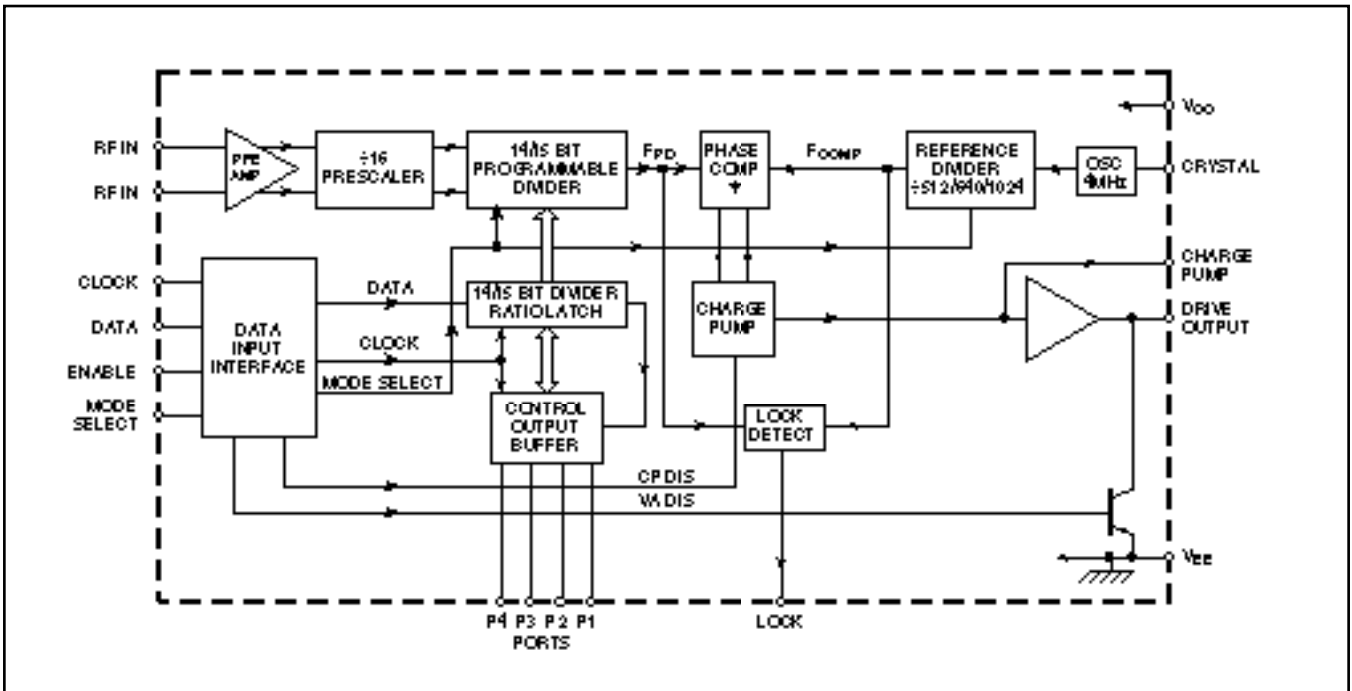


Fig. 3 Block diagram of SP5054

| Mode | Mode Select input voltage                    | Programmable divider bit length | Reference divider ratio | Frequency step size (kHz) * | Maximum operating frequency (GHz) * |
|------|--|---------------------------------|-------------------------|-----------------------------|-------------------------------------|
| 3    | 0.925V <sub>CC</sub> to V <sub>CC</sub>      | 14                              | 512                     | 125                         | 2.0479                              |
| 2    | 0.675V <sub>CC</sub> to 0.825V <sub>CC</sub> | 15                              | 512                     | 125                         | 2.5                                 |
| 1    | Open circuit                                 | 15                              | 1024                    | 62.5                        | 2.0479                              |
| 0    | 0V to 0.325 V <sub>CC</sub>                  | 15                              | 640                     | 100                         | 2.5                                 |

Table 1 SP5054 modes of operation. \* Frequencies stated apply when using a 4MHz crystal.

**FUNCTIONAL DESCRIPTION**

The SP5054 contains all the elements necessary, with the exception of reference crystal, loop filter and external high voltage transistor, to control a voltage controlled local oscillator, so forming a PLL frequency synthesised source.

The system is controlled by a microprocessor via a standard Data, Clock and Enable three-wire data bus.

The data load normally consists of a single word, which contains the frequency and port information, and is only transferred to the internal data shift register during an enable high period.

The clock input is disabled during enable low periods. New data words are only accepted by the internal data buffers from the shift register on a negative transition of the Enable, so giving improved fine tune facility for digital AFC etc.

The data sequence and timing follows the format shown in Fig. 4.

The frequency is set by loading the programmable divider with the required 14/15 bit divisor word. The output of this divider, F<sub>PD</sub>, is fed to the phase comparator where it is compared in phase and frequency domain to the internally generated comparison frequency, F<sub>COMP</sub>.

F<sub>COMP</sub> is obtained by dividing the output of an on-chip crystal controlled oscillator. The crystal frequency used is generally 4MHz, which gives an F<sub>COMP</sub> of 3.90625/6.25/

7.8125kHz and, when multiplied back up to the synthesised LO, gives a minimum step size of 62.5/100/125kHz, respectively.

The programmable divider is preceded by an input RF preamplifier and high speed, low radiation prescaler. The preamplifier is arranged to be self oscillating, so giving excellent input sensitivity.

The SP5054 contains an improved lock detect circuit which generates a flag when the loop has attained lock. 'In lock' is indicated by high impedance state.

The SP5054 contains 4 general purpose open collector outputs, ports P1-P4, which are capable of sinking at least 10mA. These outputs are set by the remaining four bits within the normal data word.

**NOTES ON PIN COMPATIBILITY**

The SP5054 may be used in SP5055 applications which require 3-wire bus as opposed to I<sup>2</sup>C bus data format. In SP5055 applications where the reference crystal is grounded to pin 3, a small modification is required to ground the crystal as shown in Fig. 5.

Appropriate connections must also be made to the Mode Select input (see Table 1). In Mode 3, The SP5054 is programming compatible with the Toshiba TD6380, in Modes 0 and 2 with the TD6381 and in Mode 1 with the TD6382.

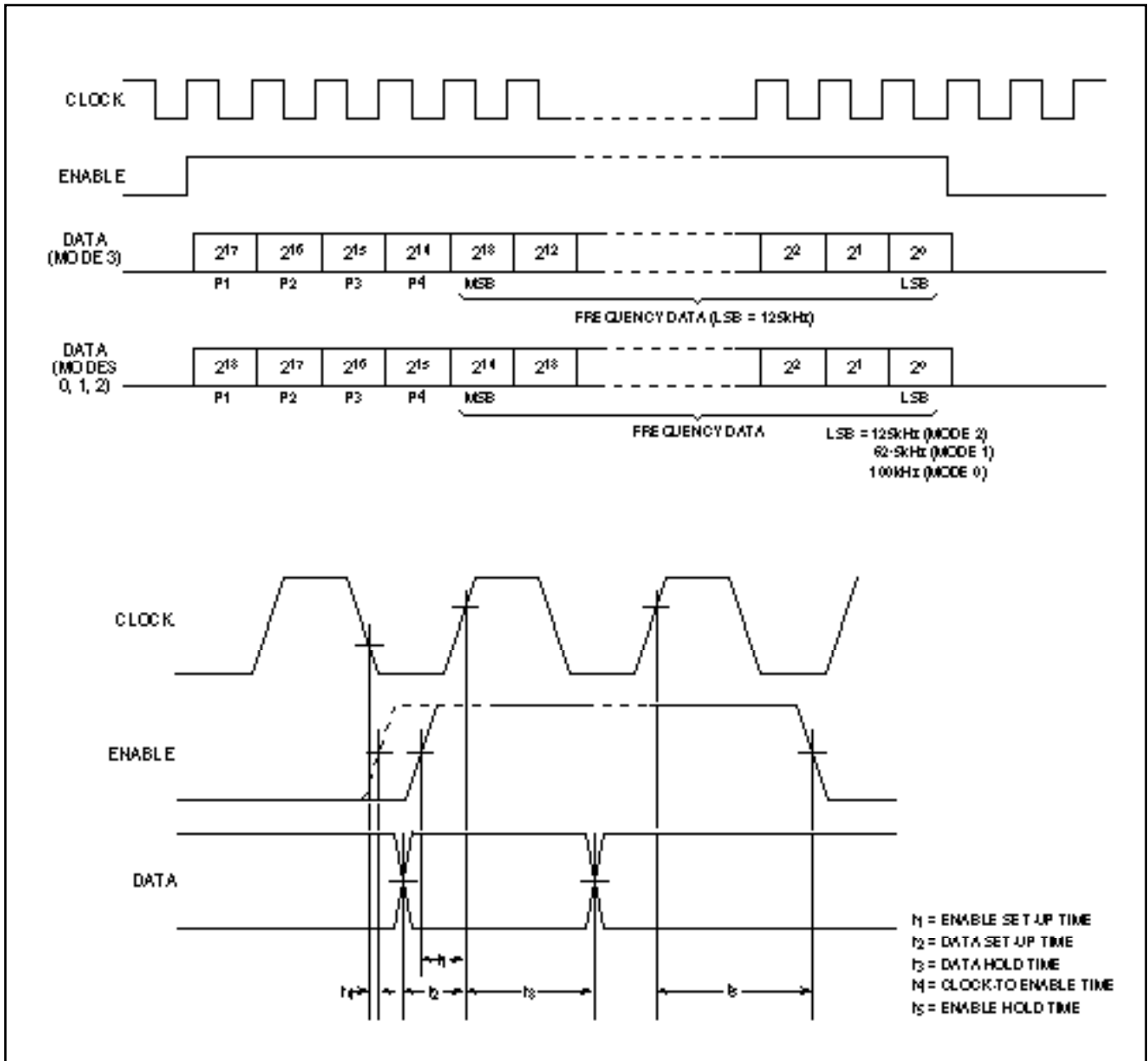


Fig. 4 Data format and timing

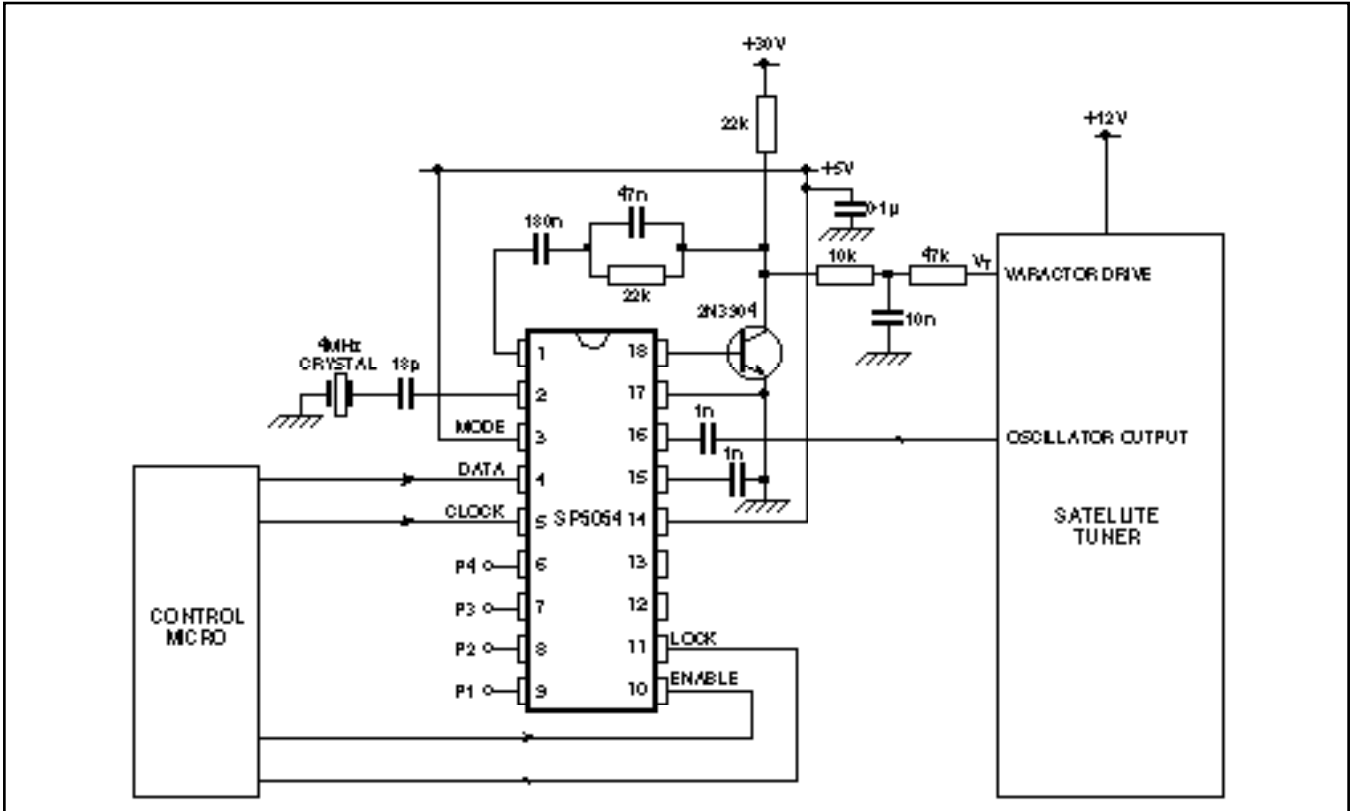


Fig. 5 Typical application ( $f_{STEP} = 125kHz$ )

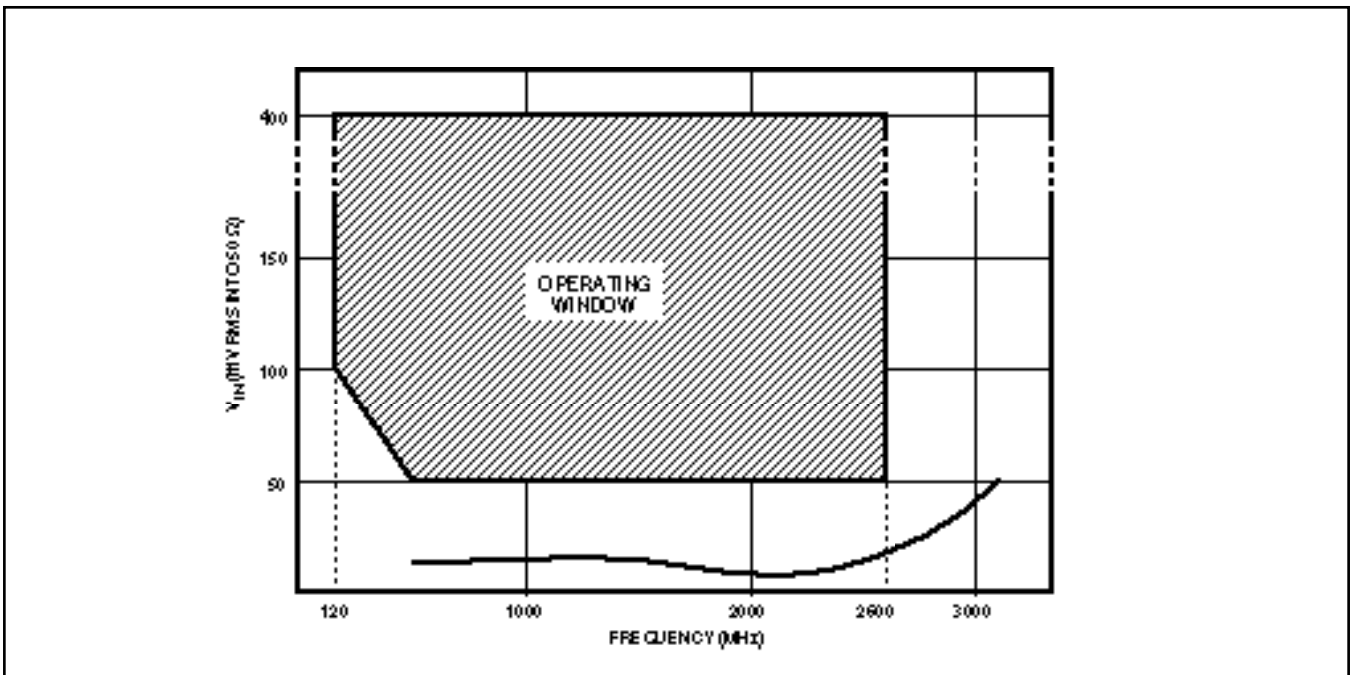


Fig. 6 Typical input sensitivity

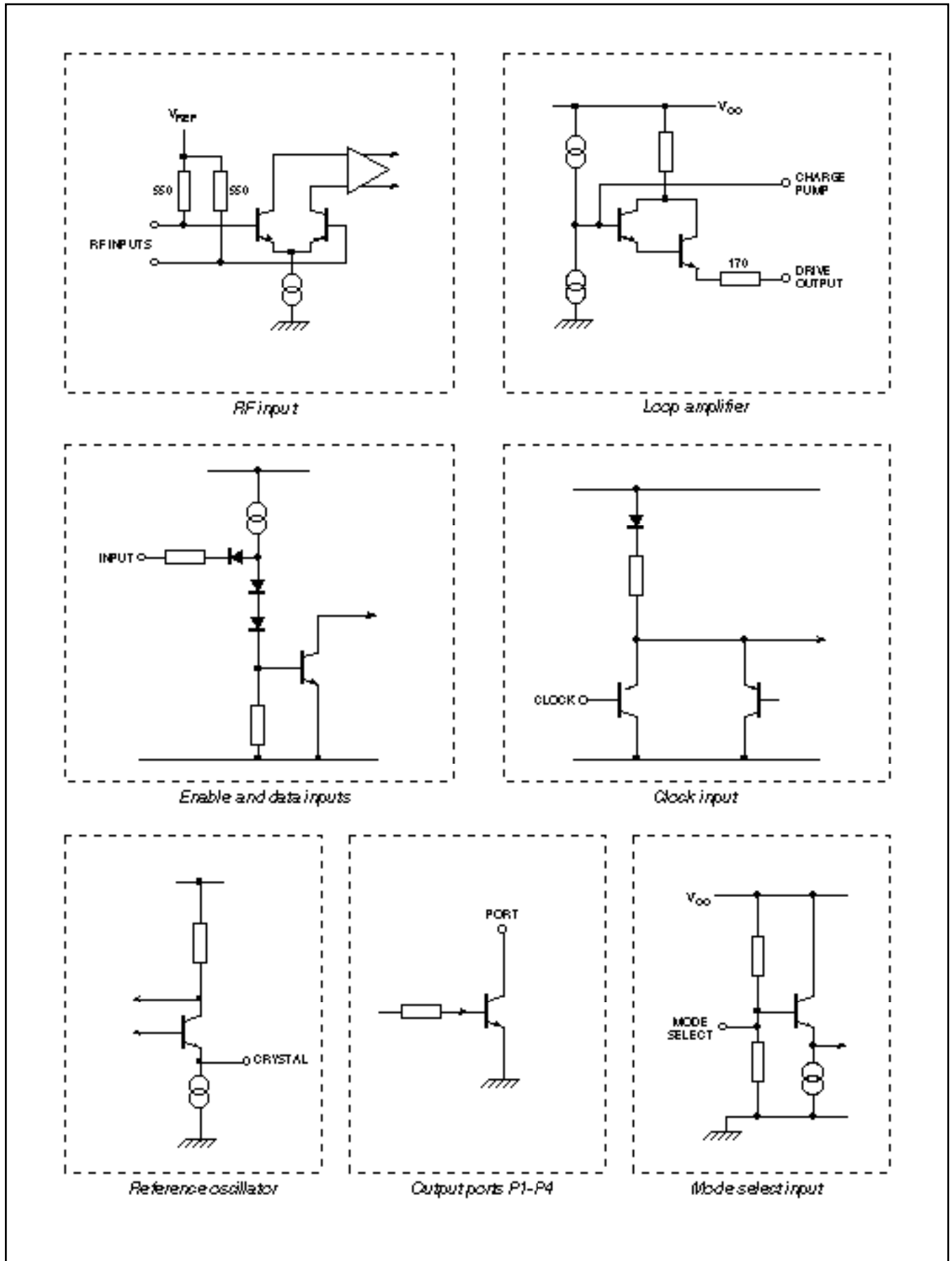
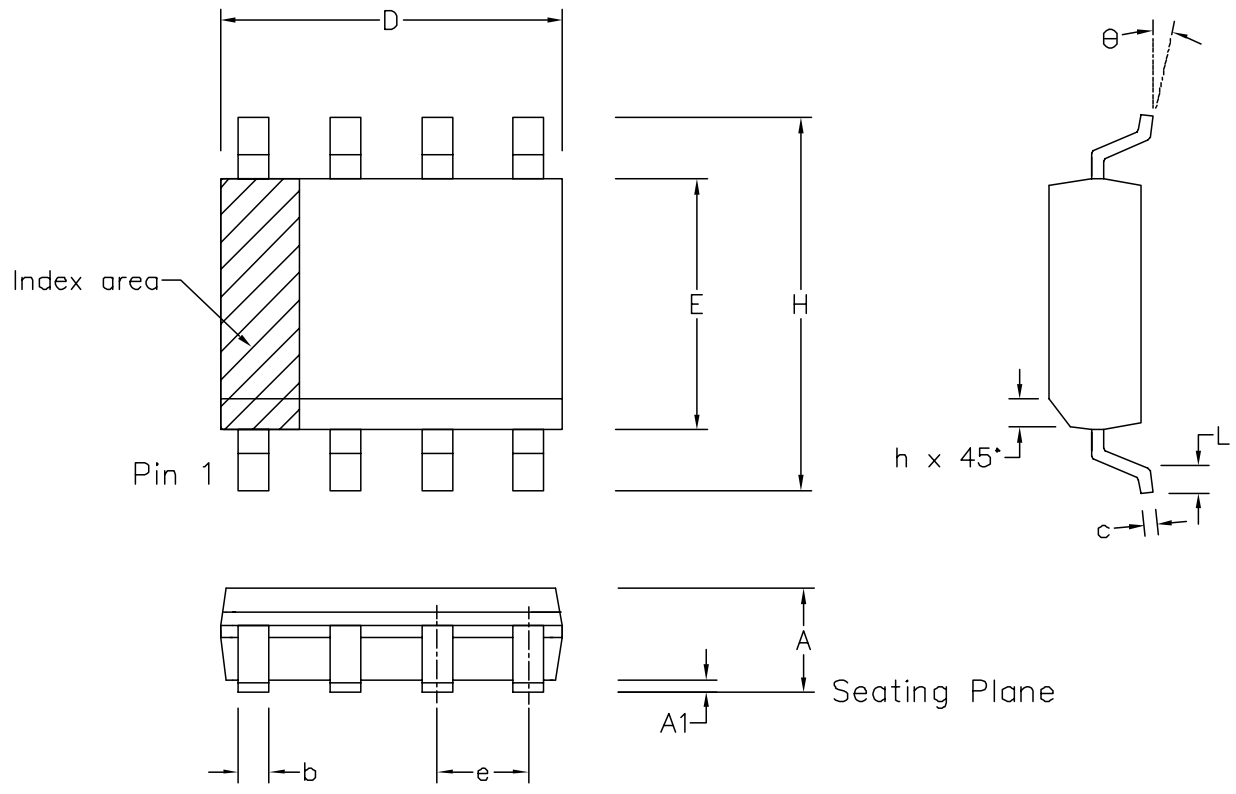


Fig. 7 SP5054 input/output interface circuits



|                                   | Min mm   | Max mm | Min inch  | Max inch |
|-----------------------------------|----------|--------|-----------|----------|
| A                                 | 1.35     | 1.75   | 0.053     | 0.069    |
| A1                                | 0.10     | 0.25   | 0.004     | 0.010    |
| D                                 | 9.80     | 10.00  | 0.386     | 0.394    |
| H                                 | 5.80     | 6.20   | 0.228     | 0.244    |
| E                                 | 3.80     | 4.00   | 0.150     | 0.157    |
| L                                 | 0.40     | 1.27   | 0.016     | 0.050    |
| e                                 | 1.27 BSC |        | 0.050 BSC |          |
| b                                 | 0.33     | 0.51   | 0.013     | 0.020    |
| c                                 | 0.19     | 0.25   | 0.008     | 0.010    |
| O                                 | 0°       | 8°     | 0°        | 8°       |
| h                                 | 0.25     | 0.50   | 0.010     | 0.020    |
| Pin Features                      |          |        |           |          |
| N                                 | 16       |        | 16        |          |
| Conforms to JEDEC MS-012AC Iss. C |          |        |           |          |

Notes:

1. The chamfer on the body is optional. If it not present, a visual index feature, e.g. a dot, must be located within the cross-hatched area.
2. Controlling dimension are in inches.
3. Dimension D do not include mould flash, protusion or gate burrs. These shall not exceed 0.006" per side.
4. Dimension E1 do not include inter-lead flash or protusion. These shall not exceed 0.010" per side.
5. Dimension b does not include dambar protusion/intrusion. Allowable dambar protusion shall be 0.004" total in excess of b dimension.

|                     |        |         |         |        |  |
|---------------------|--------|---------|---------|--------|--|
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