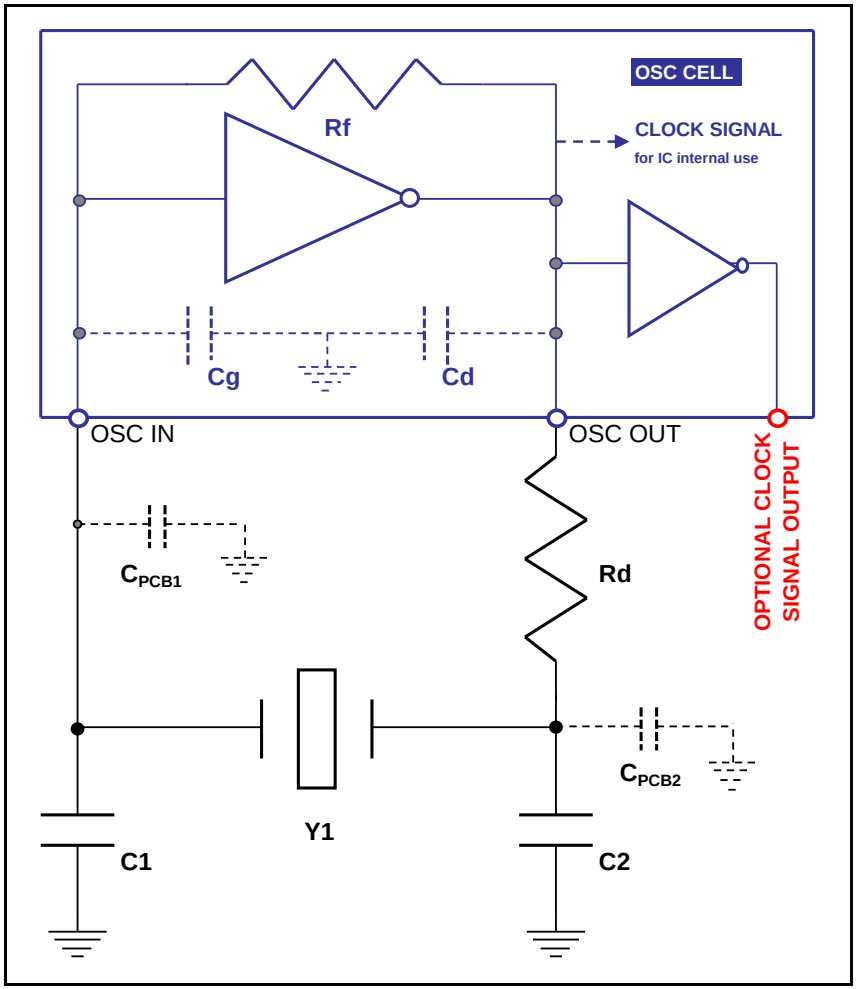
Load Capacitance



TYPICAL OSCILLATOR CIRCUIT

OSC CELL = oscillator circuit integrated into any IC.
Rf = feedback resistor, sometimes integrated in IC or is required as external resistor
Cg = capacitance of oscillator input
Cd = capacitance of oscillator output
Rd = Phase shift resistor, necessary at lower frequencies to meet oscillation condition that phase shift all the way around the oscillator loop need to add up to 360°.
Y1 = Quartz crystal unit
C1 and C1 = external load capacitors.
C_{PCB1} and C_{PCB2} = stray capacitances of PCB traces

The total LOAD CAPACITANCE of the oscillator circuit is the sum of all capacitances. consisting of:
1. The two external capacitors (here called C1 and C2)
2. The IC input and output capacitances (here called Cg and Cd)
3. The stray capacitances of PCB traces (here called CPCB1 and CPCB2)

Commonly being only the values of the external capacitors known so that a correct calculation of the actual load capacitance is not possible.
In such case we use simlified formula to calculate the load capacitance as:

$$CL_{TOTAL} = \frac{C1 \times C2}{C1 + C2} + C_{STRAY}$$

Here C1 and C2 are the external capacitors in the cricuit, values should be known.
Cstray is summarized value for IC input and output capacitance and the PCB traces.
Cstray in a 3.3VDC circuit is often 3~4pF.
Cstray in a 5.0VDC circuit often 5~7pF.
However, we have also seen circuits that had large deviation from these values.

Author: MB/QA/QE

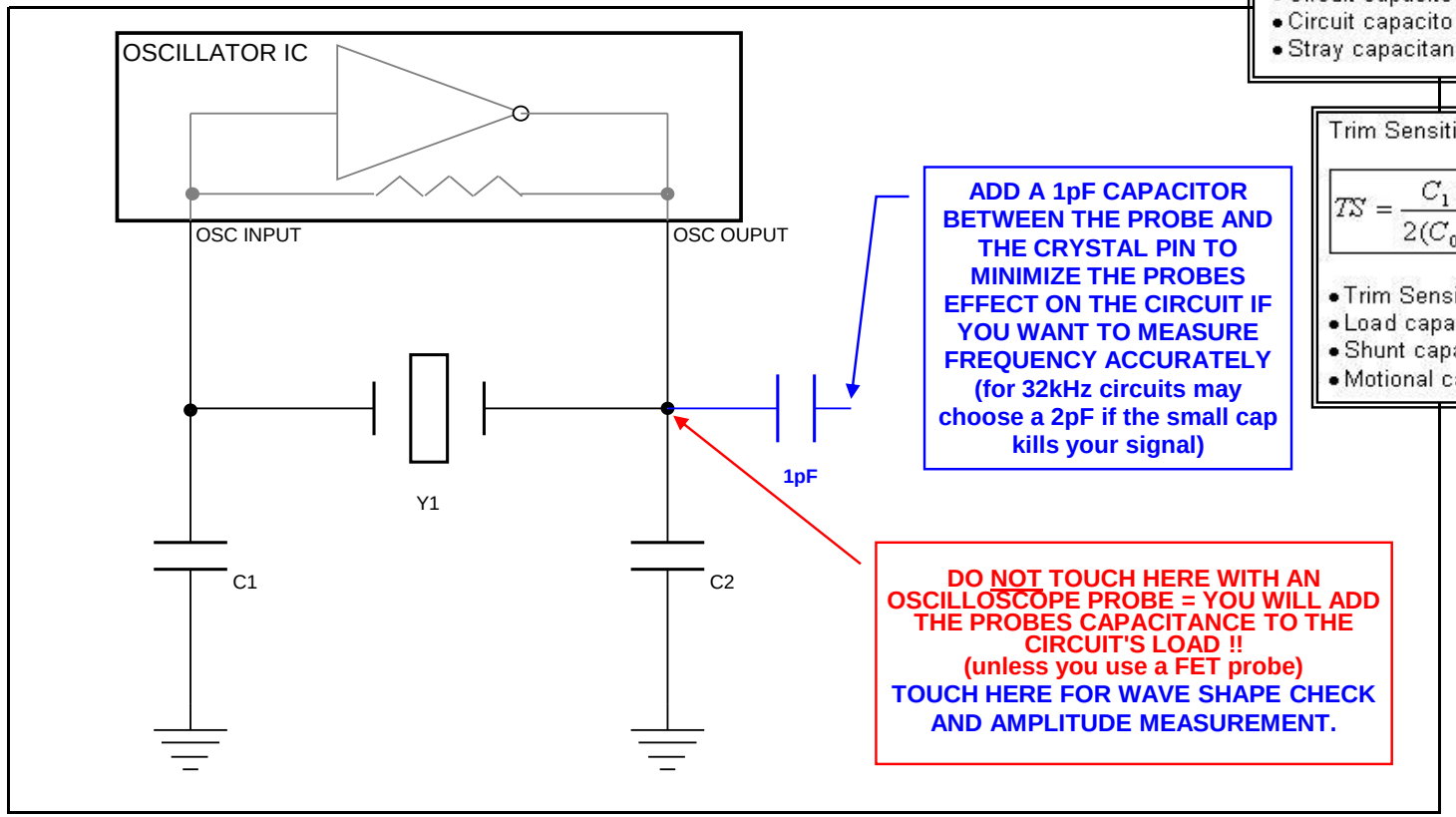
Load Cap Measurements

TOTAL LOAD CAPACITANCE FOR CRYSTAL Y1 IS THE SUM OF:

(1) Capacitance of load capacitors C_L1 and C_L2.
(2) Capacitance of IC INPUT and OUPUT.
(3) Stray capacitance of PCB traces.

Based on the crystals Trim Senisitivity, the frequency will change if total load capacitance changes.

Typical schematics of a crystal oscillator circuit is shown below.



Total Load Capacitance CL in an oscillator circuit can be calculated as:

$$CL_{TOTAL} = \frac{C1 \times C2}{C1 + C2} + C_{STRAY}$$

- Total load capacitance CL_{TOTAL} [pF]
- Circuit capacitor C1 [pF]
- Circuit capacitor C2 [pF]
- Stray capacitance C_{STRAY} [pF]

Trim Sensitivity of Quartz Crystal

$$TS = \frac{C_1 \times 1000}{2(C_0 + C_L)^2}$$

- Trim Sensitivity [ppm/pF]
- Load capacitance C_L [pF]
- Shunt capacitance C_0 [pF]
- Motional capacitance C_1 [fF]