The transistor as a sine-wave generator (oscillator)

Experiment Objectives

- Learning about the Wien bridge electronic oscillator
- Setting the sine wave by modifying the operating points
- Determining the oscillation frequency for different RC elements

Basic Information

The Wien bridge oscillator is a transistor circuit that produces sine waves. The Wien bridge is the component that determines the frequency. This circuit part is composed of a series connection and a parallel connection with a resistor and a capacitor in each. Both of these RC elements are in turn connected in series, where *R* and *C* are usually chosen to have the same value in each case. That results in a bandpass with a frequency for which: $f = \frac{1}{2\pi \cdot RC}$ (1)

Since the Wien bridge is in an oscillator circuit's feedback, the frequency at the output can be picked up in a stable manner if the phase condition φ = 0° is maintained between the input signal and the feedback signal. This is achieved by having both transistor stages in the circuit shift each signal in the common emitter by 180°.

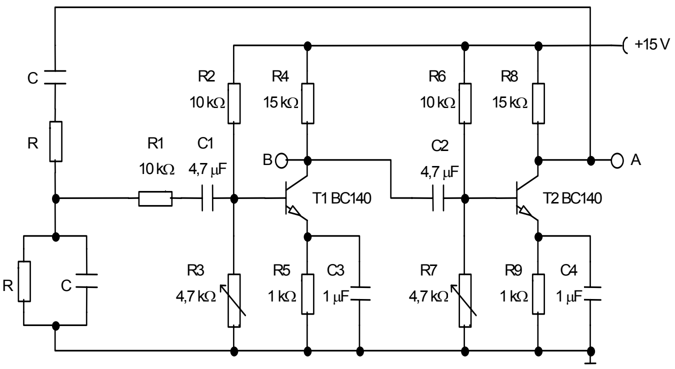
A change in the oscillation frequency is studied by switching the resistors *R* and the capacitors *C*.

Apparatus

1 Plug-in board DIN A4	576 74
1 Set of 10 bridging plugs	501 48
2 STE Transistors BC 140, NPN, emitter bottom	578 76
2 STE Resistors 1 kΩ, 1.4 W, 5 %	577 44
3 STE Resistors 10 kΩ, 0.5 W	577 56
2 STE Resistors 15 kΩ, 0.5 W	577 58
2 STE Resistors 47 kΩ, 0.5 W	577 64
2 STE Resistors 100 kΩ, 0.5 W, 1 %	577 68
2 STE Regulation resistors 4.7 kΩ, 1 W	577 81
2 STE Capacitors 100 pF, 630 V, 20 %	578 22
2 STE Capacitors 220 pF, 160 V, 20 %	578 23
2 STE Capacitors 1 µF, 100 V, 20 %	578 35
2 STE Capacitors 4.7 µF, 63 V, 5 %	578 16
1 DC power supply 0...+/- 15 V	521 45
1 Two-channel oscilloscope 303	575 211
2 Screened cables BNC/4 mm	575 24
1 Multimeter LDanalog 20	531 120
1 Connecting lead, Ø 2,5 mm², 50 cm, black	501 28
2 Pairs of cables, 50 cm, red and blue	501 45

KEM/JN 0407

Setup and Procedure



– Setup according to the illustration. At first, use the resistors *R* = 47 kΩ and the capacitors *C* = 100 pF for the Wien bridge.

– Do not attach the connecting cable for the Wien bridge's feedback yet.

– Turn on the power supply and set the operating voltage to 15 V.

Setting the operating point:

– Use the multimeter to measure the voltage $U_{BE,1}$ at the transistor T1 (left transistor).

– Set the regulation resistor R3 so that the transistor T1 just becomes conductive, i.e. the voltage $U_{BE,1}$ rises to about 0.55 V.

– Use the multimeter to measure the voltage $U_{BE,2}$ at the transistor T2 (right transistor).

– Set the regulation resistor R7 so that the transistor T2 just becomes conductive, i.e. the voltage $U_{BE,2}$ rises to about 0.55 V.

a) Observing the sine wave

– Attach the connecting cable for the feedback over the Wien bridge.

– Observe the curve of the output voltage U_A at point A to ground with the oscilloscope.

– If necessary, readjust the operating point using the regulation resistors R3 and R7, such that a sinusoidal output voltage is produced.

– Determine the oscillator frequency *f*.

b) Measuring the phase shift

– Observe with the oscilloscope and compare the curve of the output voltage U_A at point A (transistor T2's collector, feedback signal) as well as the voltage curve at point B (transistor T1's collector, input signal) to ground.

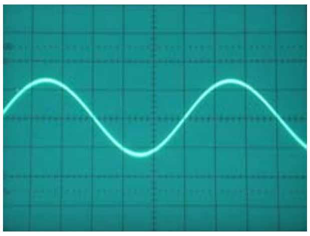
c) Measuring the oscillator frequency with different RC elements

– Swap pairwise the Wien bridge's resistors R and capacitors *C* according to the table and determine the oscillator frequency *f*.

– If necessary, readjust the operating point using the regulation resistors R3 and R7, such that a sinusoidal output voltage is produced.

Measurement Examples and Results

a) Observing the sine wave

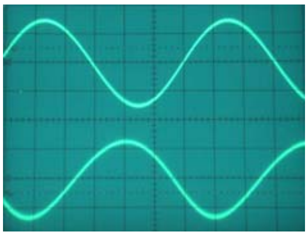


Y I: 0.5 V/div AC
Sweep: 5 µsec/div

– The Wien bridge oscillator produces a sinusoidal output voltage.

– Measured oscillation frequency: *f* = 32.1 kHz

b) Measuring the phase shift



(A) Y I: 0.5 V/div AC
(B) Y II: 10 mV/div AC
Sweep: 5 µsec/div

– The two sinusoidal voltages are shifted by about 180° one from the other so that the feedback signal is fed in phase again.

c) Measuring the oscillator frequency with different RC elements

$\frac{R}{\text{k}\Omega}$	$\frac{C}{\text{pF}}$	$\frac{f}{\text{kHz}}$
47	100	32.1
100	100	24.4
47	220	20.8
100	220	16.1

– The Wien bridge oscillator's output frequency can be varied by changing the Wien bridge's capacities and resistances.

– The greater the resistance in the Wien bridge, the lower the oscillator frequency.

– The greater the capacity in the Wien bridge, the lower the oscillator frequency.

– Summary:

The smaller $\frac{1}{R \cdot C}$ is, the greater the oscillator frequency *f*.

LD Didactic GmbH . Leyboldstrasse 1 . D-50354 Huerth / Germany . Phone: (02233) 604-0 . Fax: (02233) 604-222 . e-mail: info@ld-didactic.de