Expt 6 – Opamp Amplifiers

EE 230 Analog Circuits Lab

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2021-22/I

Summary

- Part A - Intro to General Purpose Opamps and LM 741
- Part B – Inverting Amplifier Configuration
- Part C – Non-inverting Amplifier Configuration
- Part D – Single-Opamp Difference Amplifier

Part A - Intro to General Purpose Opamps and LM 741

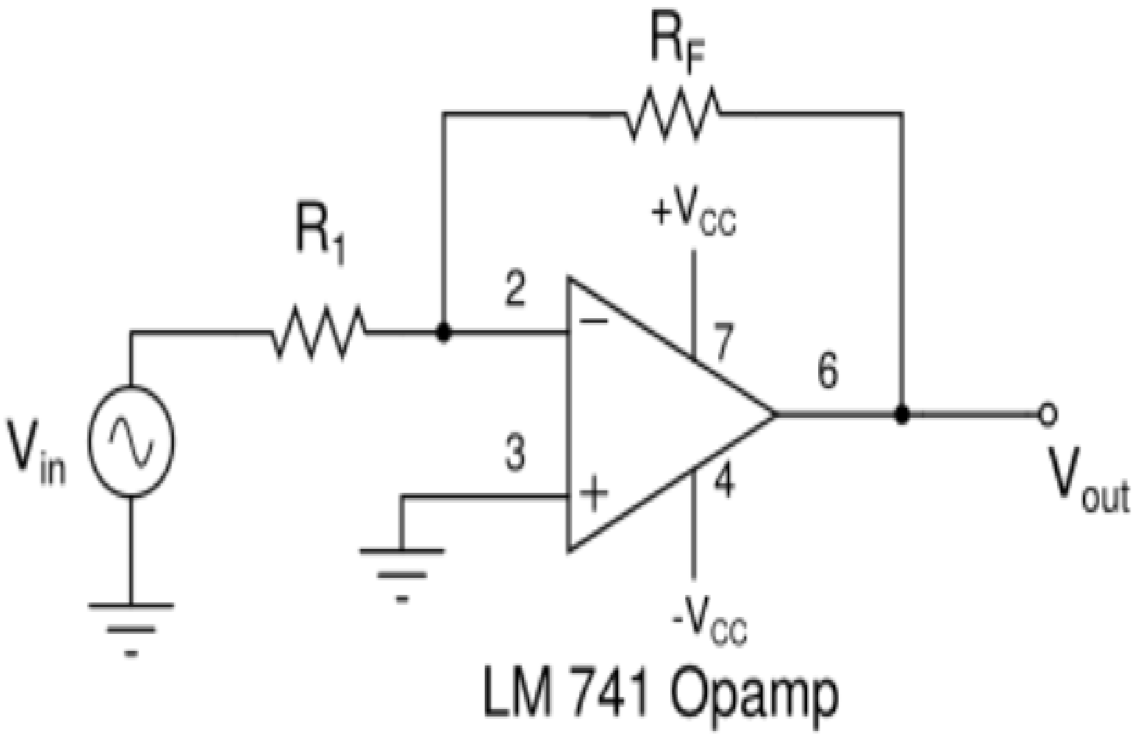
DC Open-loop gain : $2x10^5$ V/V
Open-loop input resistance: 2 MΩ
Slew rate : 0.5 V/μs

Open-loop cut-off frequency : 5 Hz
Open-loop Output resistance : 75 Ω
CMRR (= A_d/A_{cm}) : 90 dB

Typical Parameters of 741 General Purpose Opamp

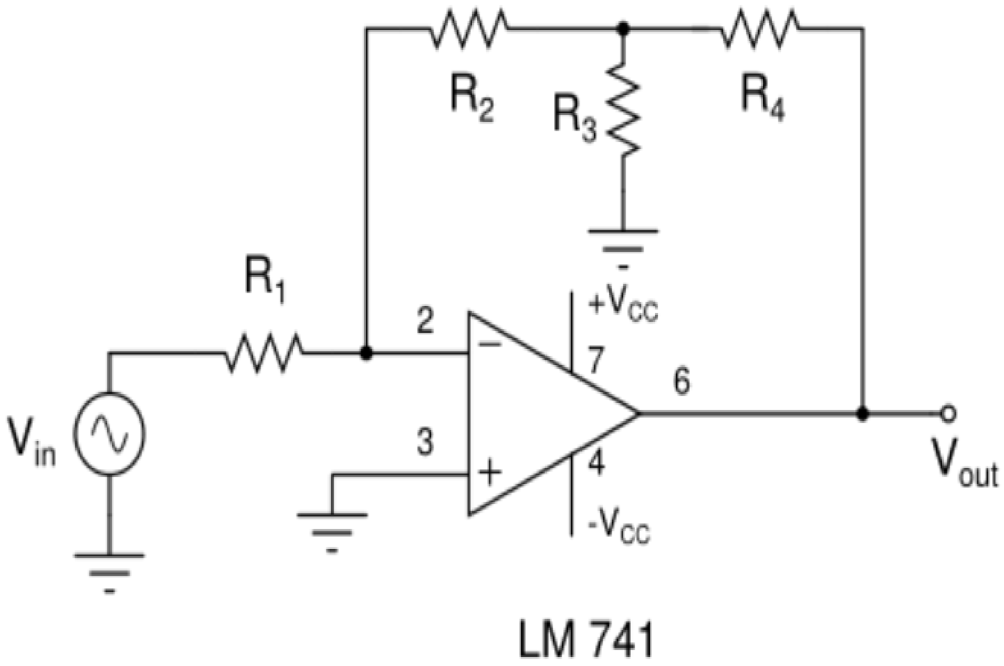
Part B – Inverting Amplifier Configuration

Part B – Inverting Amplifier Configuration



- Major features (as a Voltage Amplifiers)
- $R_{in} = R_1$
- R_{out} very low
- Not a good Voltage Amp (due to lower R_{in})
- Limited Voltage gain due to limitation on R_1
- Phase inversion between V_{in} and V_{out}

A Special Inverting Amplifier

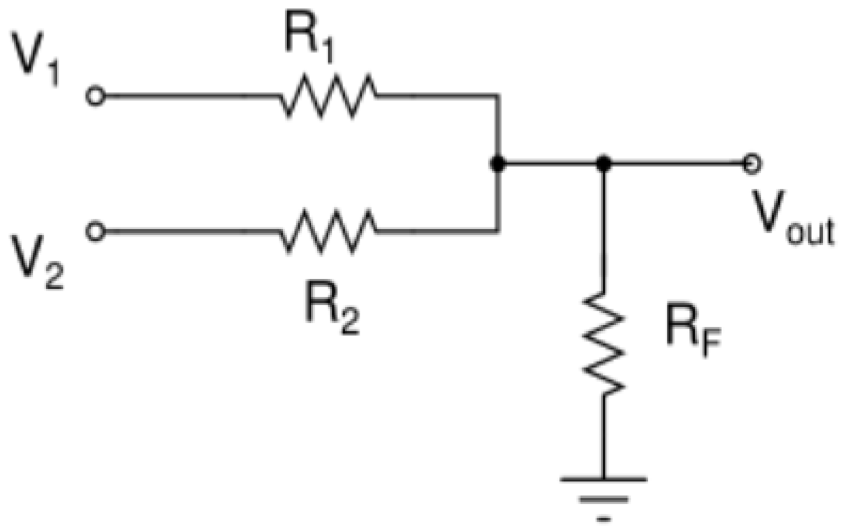


$$\frac{V_{out}}{V_{in}} = \frac{-R_2}{R_1}\left(1 + \frac{R_4}{R_2} + \frac{R_4}{R_3}\right)$$

- Expt 6 circuit values:
- $R_1 = R_2 = R_4 = 1\ \mathrm{M\Omega}$, $R_3 = 120\ \mathrm{k\Omega}$
- $R_1 = R_2 = R_4 = 1\ \mathrm{M\Omega}$
  - R_1 chosen high to take care of the R_{in} issue of the standard inverting amplifier
- High voltage gain possible
  - Expt 6: $|A_V| = 10.3$
- A good choice as a voltage amp

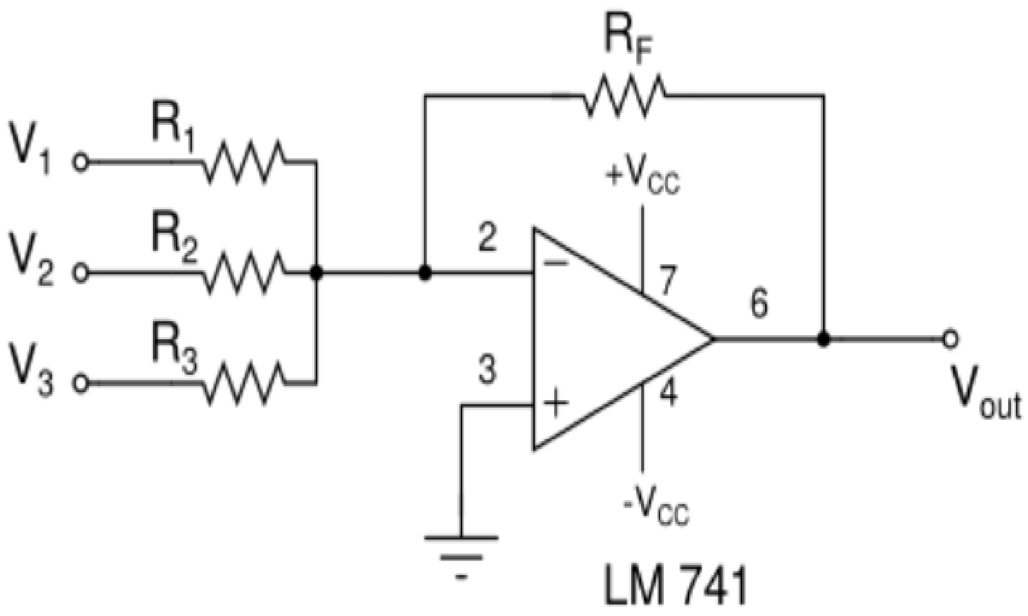
Opamp based Weighted Summer

Resistive Summer Circuit

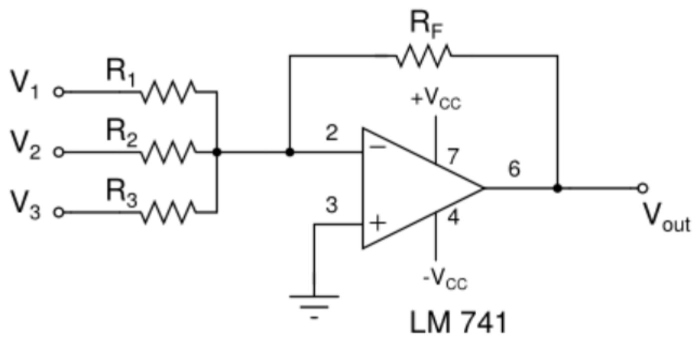


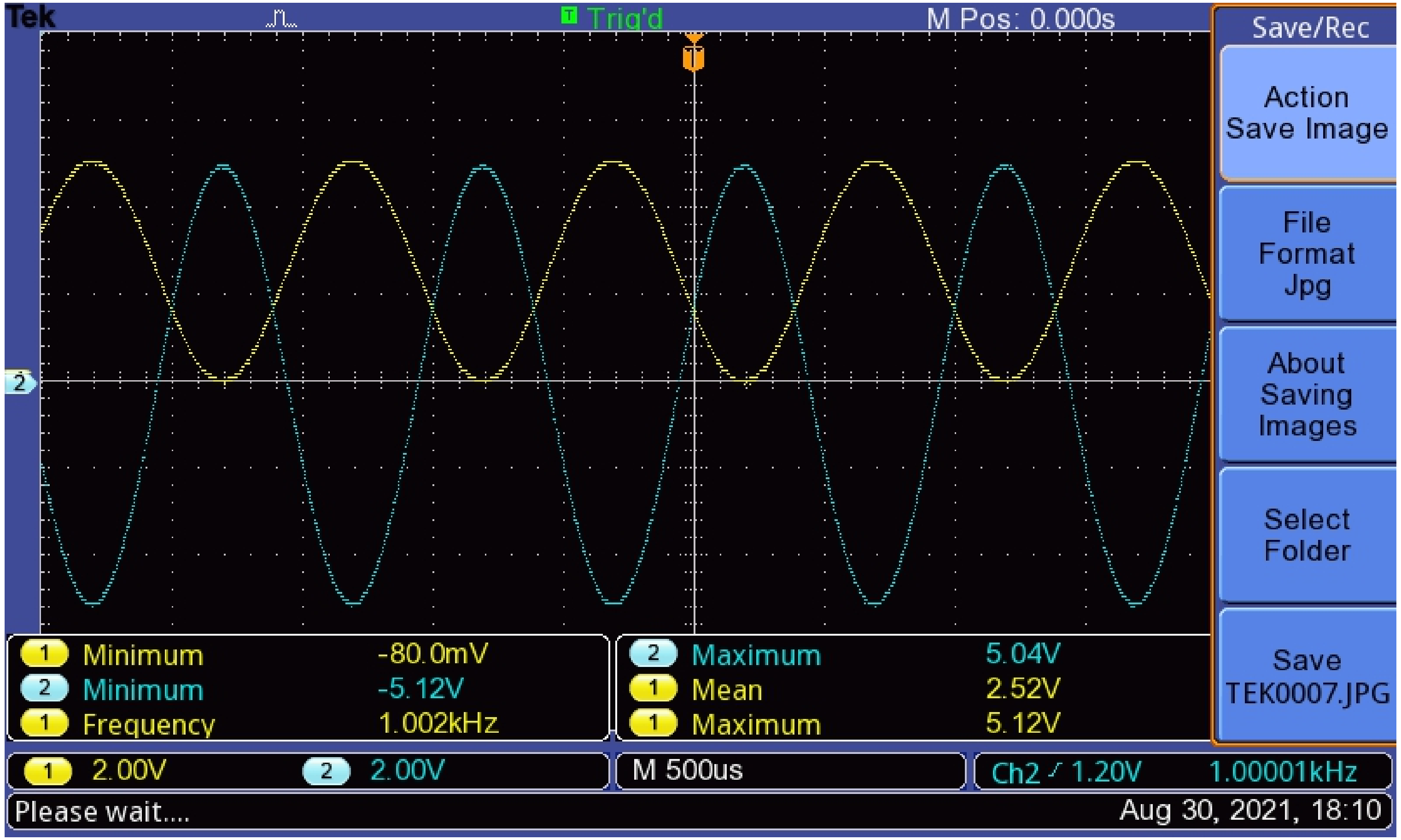
- Problems
- Weights are coupled
  - Contribution of V_1 affected by weightage of V_2
- Quite cumbersome to design
  - For more than 2 inputs
- No possibility of gain

Opamp based Weighted Summer



- Problems
- Weights are independent
  - Contribution of V_1 depends only on its weightage
- Very easy to design
  - For any number of inputs
- Voltage gain possible

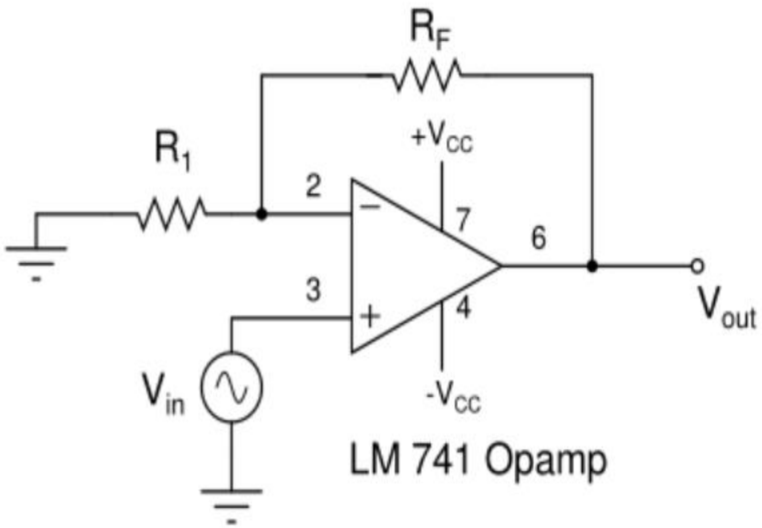




- Experiment
- $R_1 = R_2 = 6.8\ k\Omega$,
- $R_F = (6.8\ k\Omega + 6.8\ k\Omega)$
- V_1 = a unipolar sinewave (Max 5 V and Min 0 V);
- V_2 = -2.5 V dc)
- Vout : 5 sin ωt

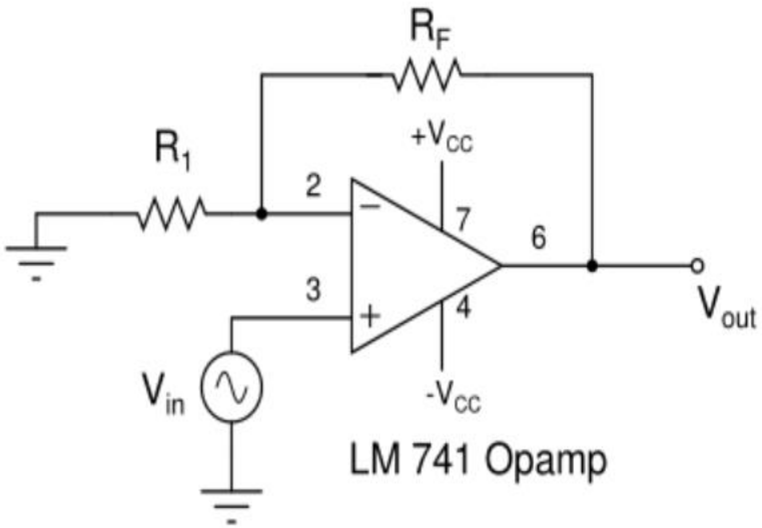
Part C – Non-inverting Amplifier

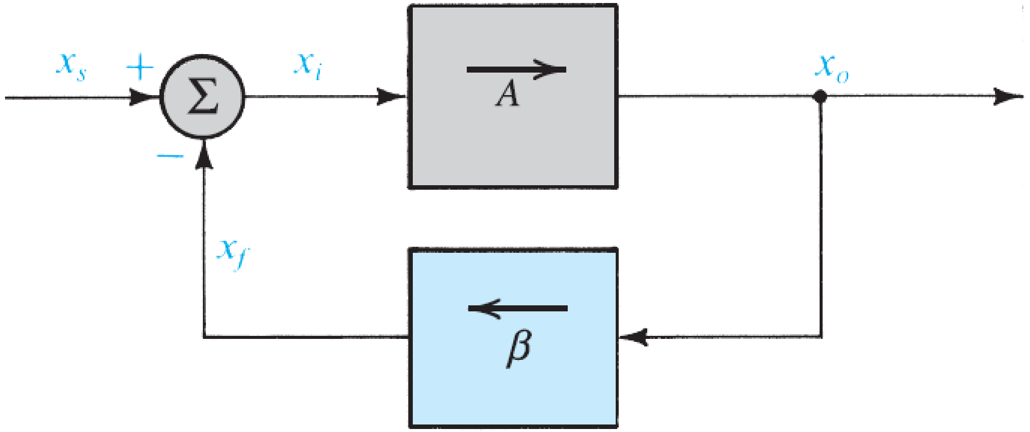
Non-inverting Amplifier



- Major features (as a Voltage Amplifiers)
- R_{in} very high
- R_{out} very low
- Choice of R_1 and R_F
  - Based on input bias current
- Excellent voltage amplifier

Closed-loop Gain, A_f





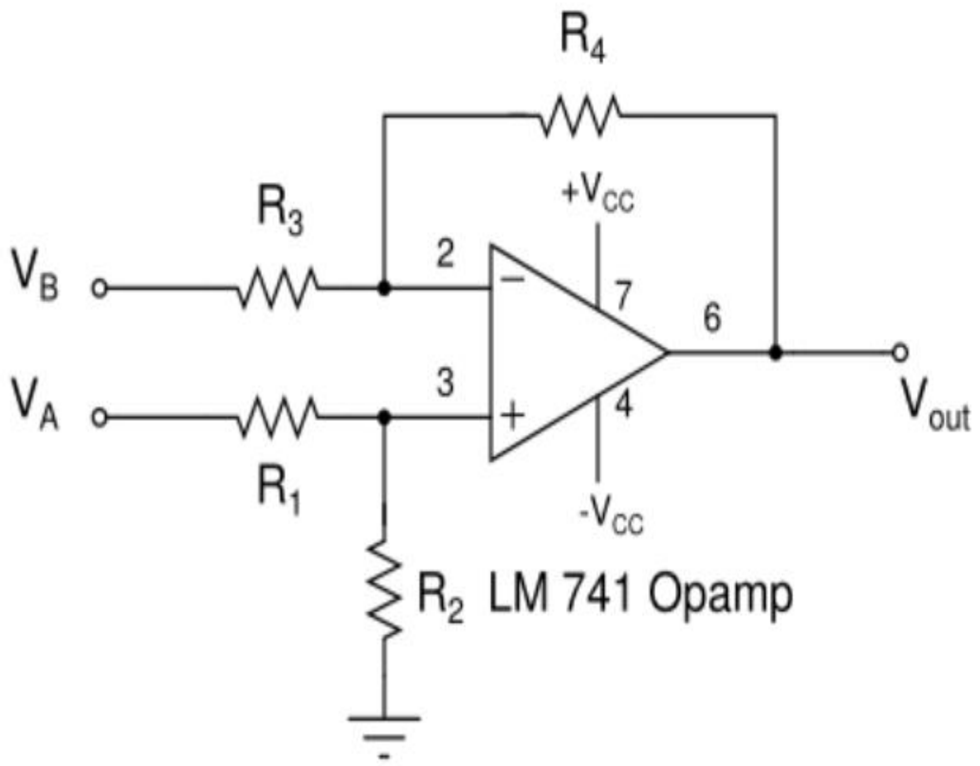
$$A_f = \frac{A}{1 + A\beta}$$

- A_f of an Non-inv amp

Source: Microelectronic Circuits – 7e, Sedra & Smith, Chap 11

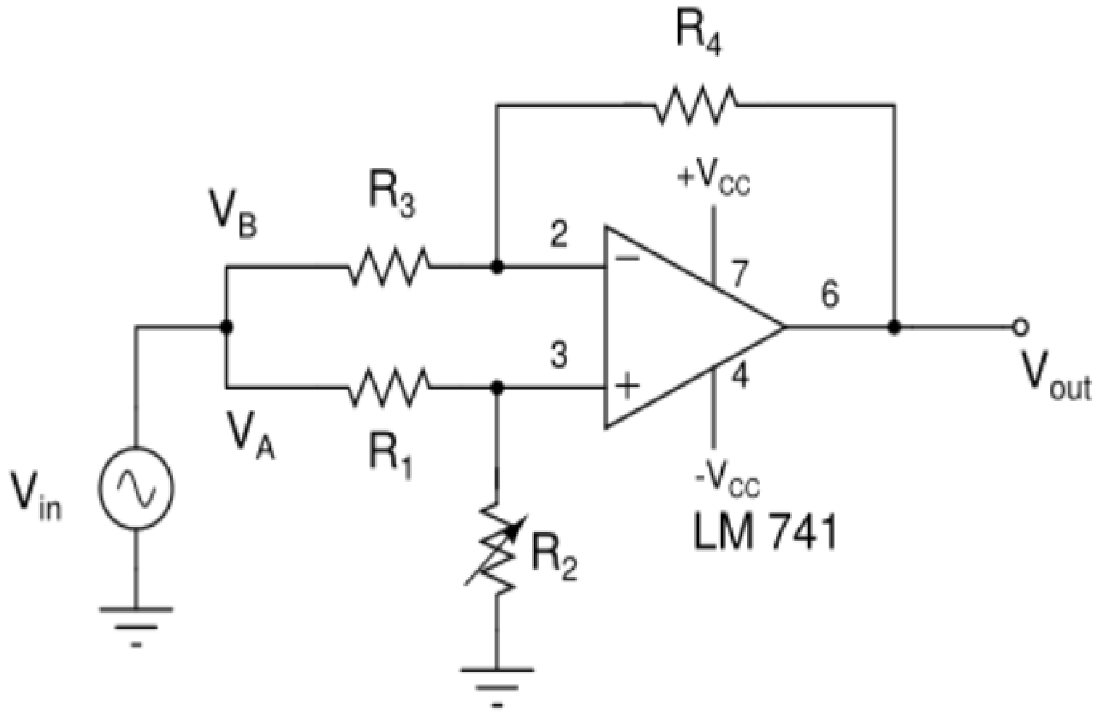
Part D – Difference Amplifier

Difference Amplifier



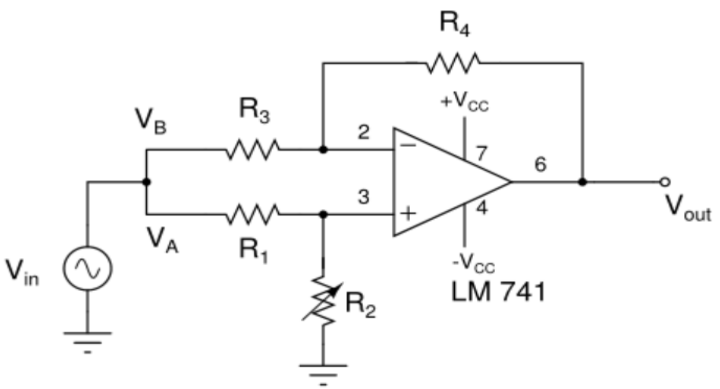
- Major Features
- Uses differential input signals
  - Inv and Non-inv used single-ended inputs
- Works as a difference amp if ($R_4/R_3 = R_2/R_1$)
- $A_d = R_4/R_3$
- $A_{cm} = 0$ ideally
- CMRR = A_d/A_{cm} (ideally ∞)

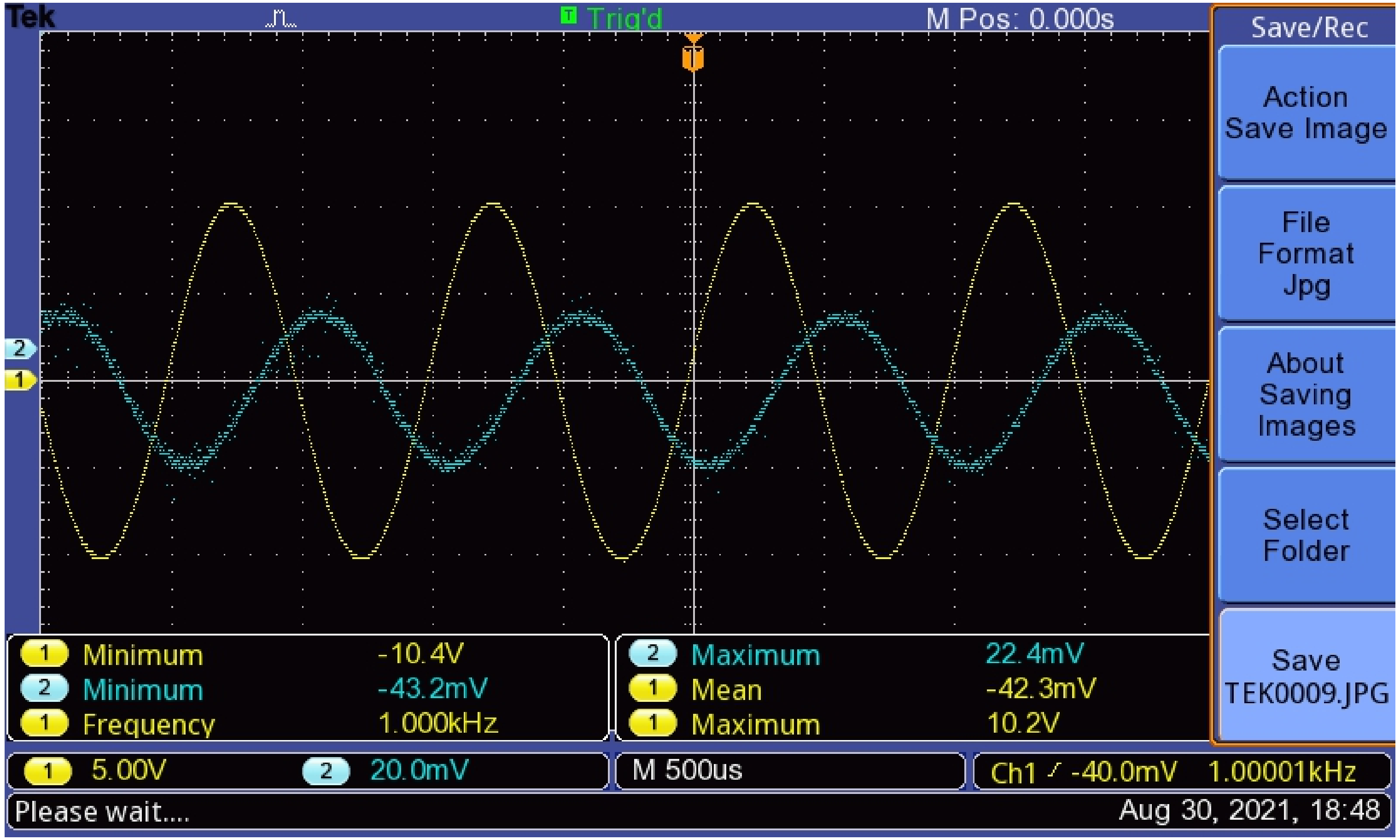
Measurement of Common-mode Gain A_{cm}



- A_{cm} is a very small quantity (10^{-3} or 10^{-4} typ)
- Difficult to measure
- Need to do a careful measurement to minimize measurement errors

- $A_{cm} = V_{out}/V_{in}$

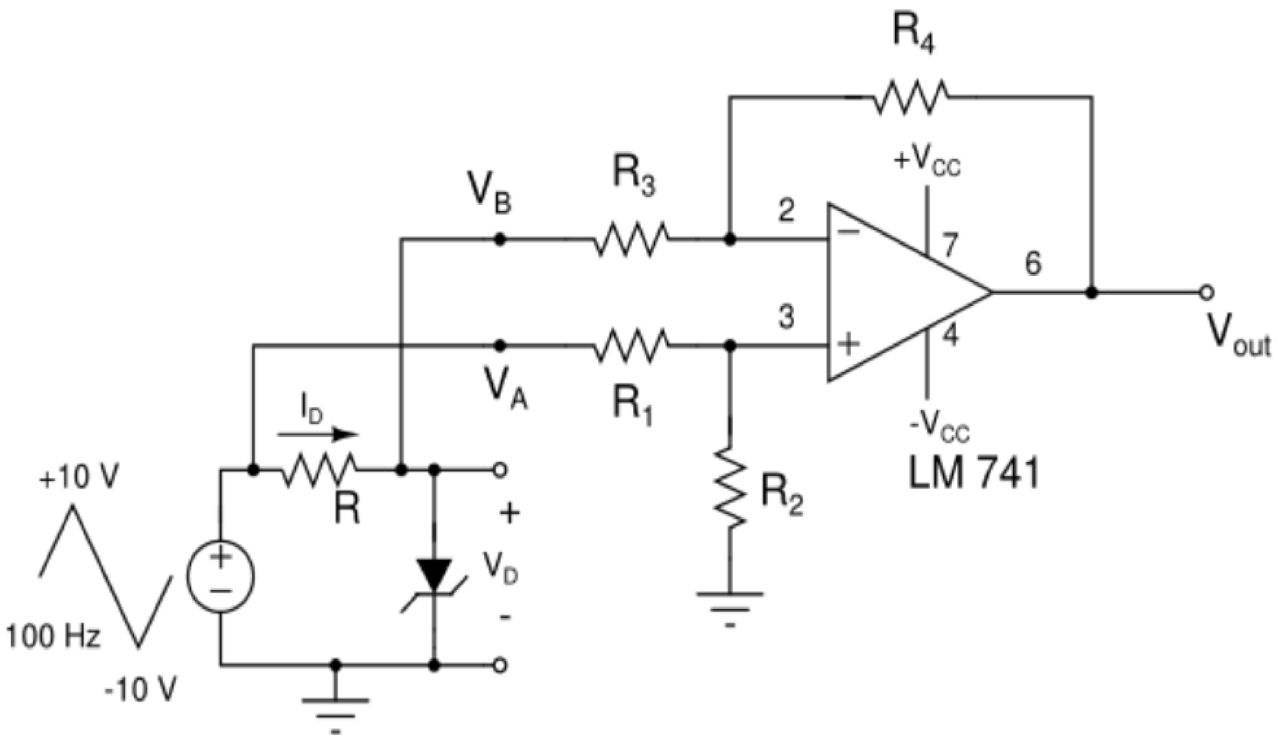




Procedure

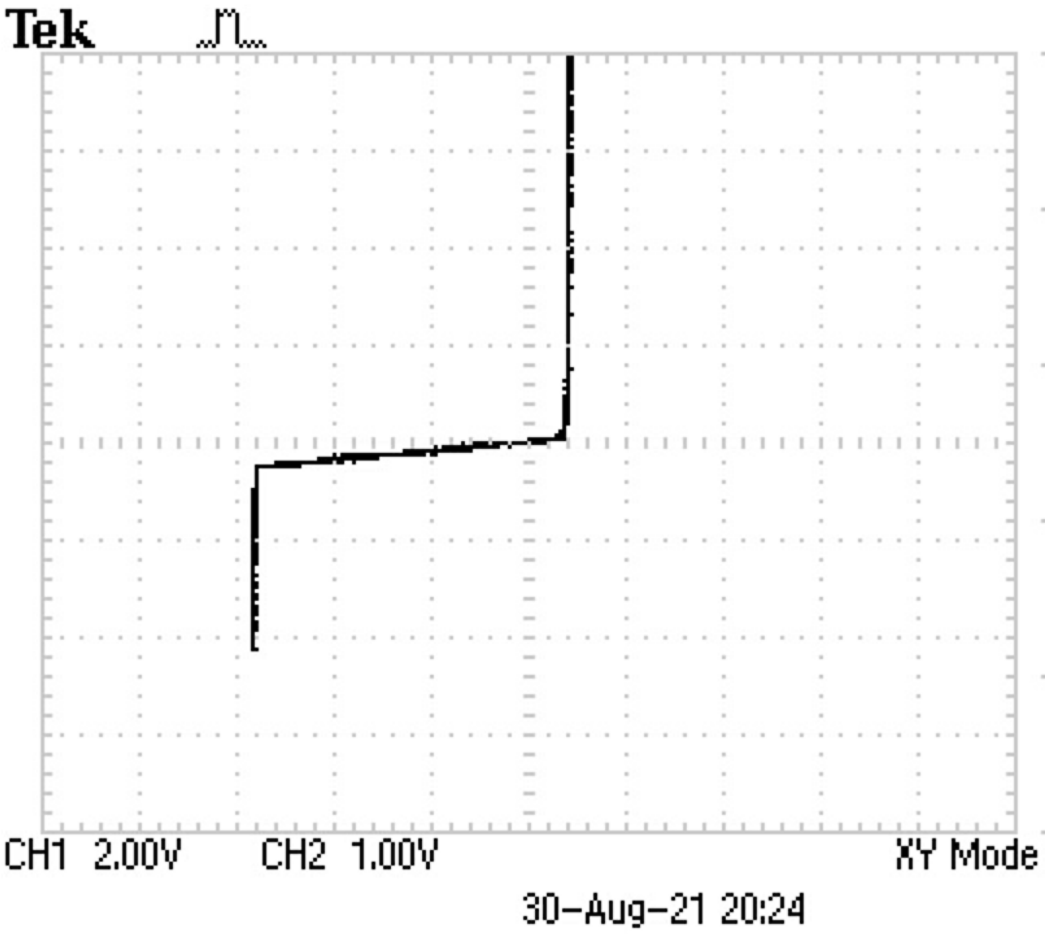
- $V_A = V_B = V_{in}$
- $V_{in} = 10 \sin \omega t$ (1 kHz)
- Adjust R_2 (to satisfy the condition, $R_2/R_1 = R_4/R_3$)
- Adjust R2 to get the minimum possible V_{out}
- $A_{cm} = V_{out}/V_{in}$

I-V Characteristics of a Zener and other Diodes

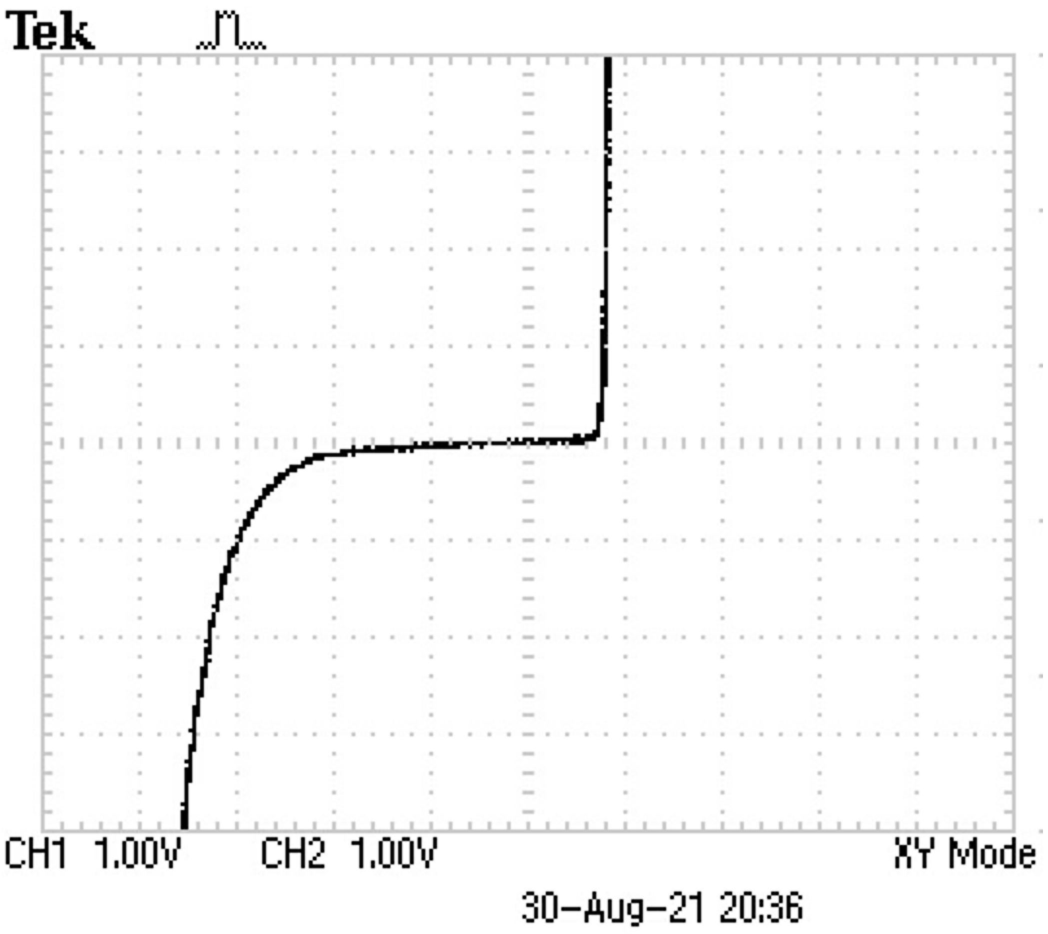


- Very useful circuit
- $R_1 = R_2 = R_3 = R_4 = 10\ k\Omega$,
- $R = 1\ k\Omega$.
- $V_{out} = (V_A - V_B) = I_D.R$
- Magnitude of V_{out} (in volts) will be the same as magnitude of I_D (in mA)
- Choice of V_{in}
  - Must be a triangular waveform
  - Must be low frequency (100 Hz to 1 kHz)

Application 1 – I-V Characteristics of a Zener Diodes

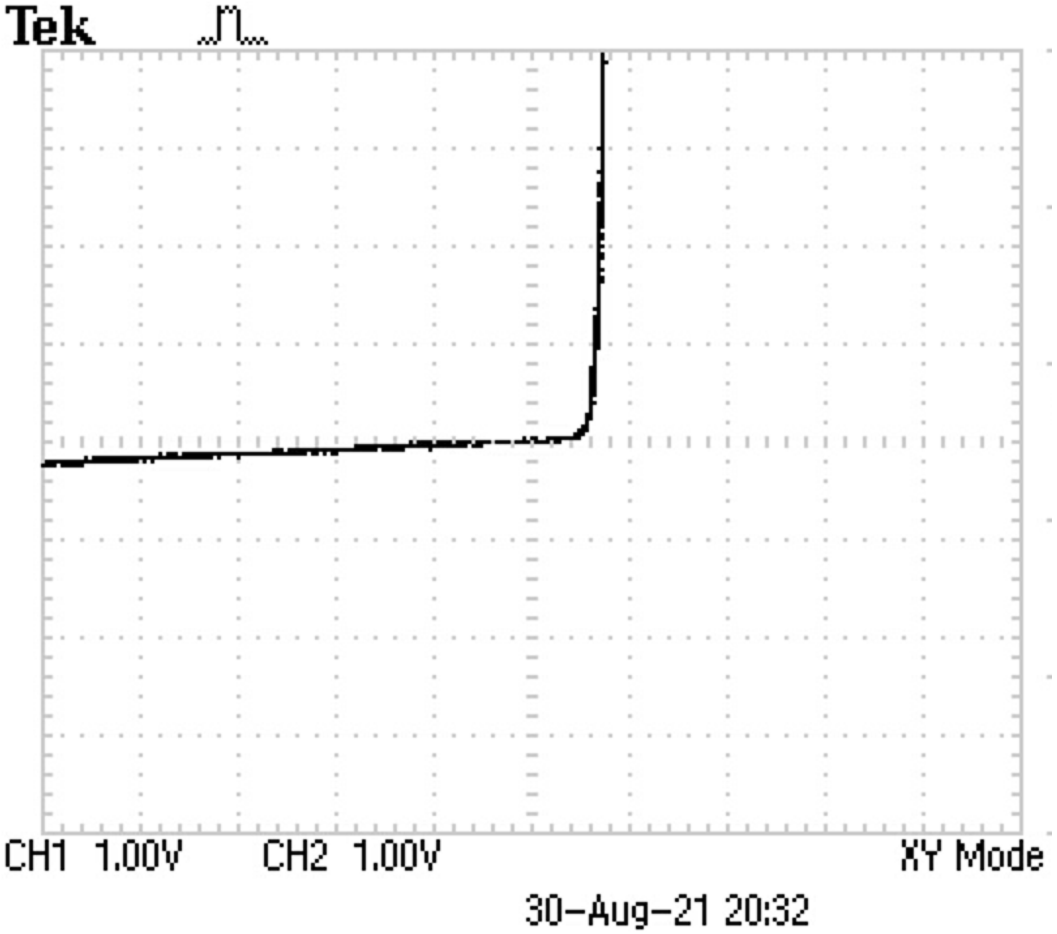


Zener 5.6 V, 1 kHz

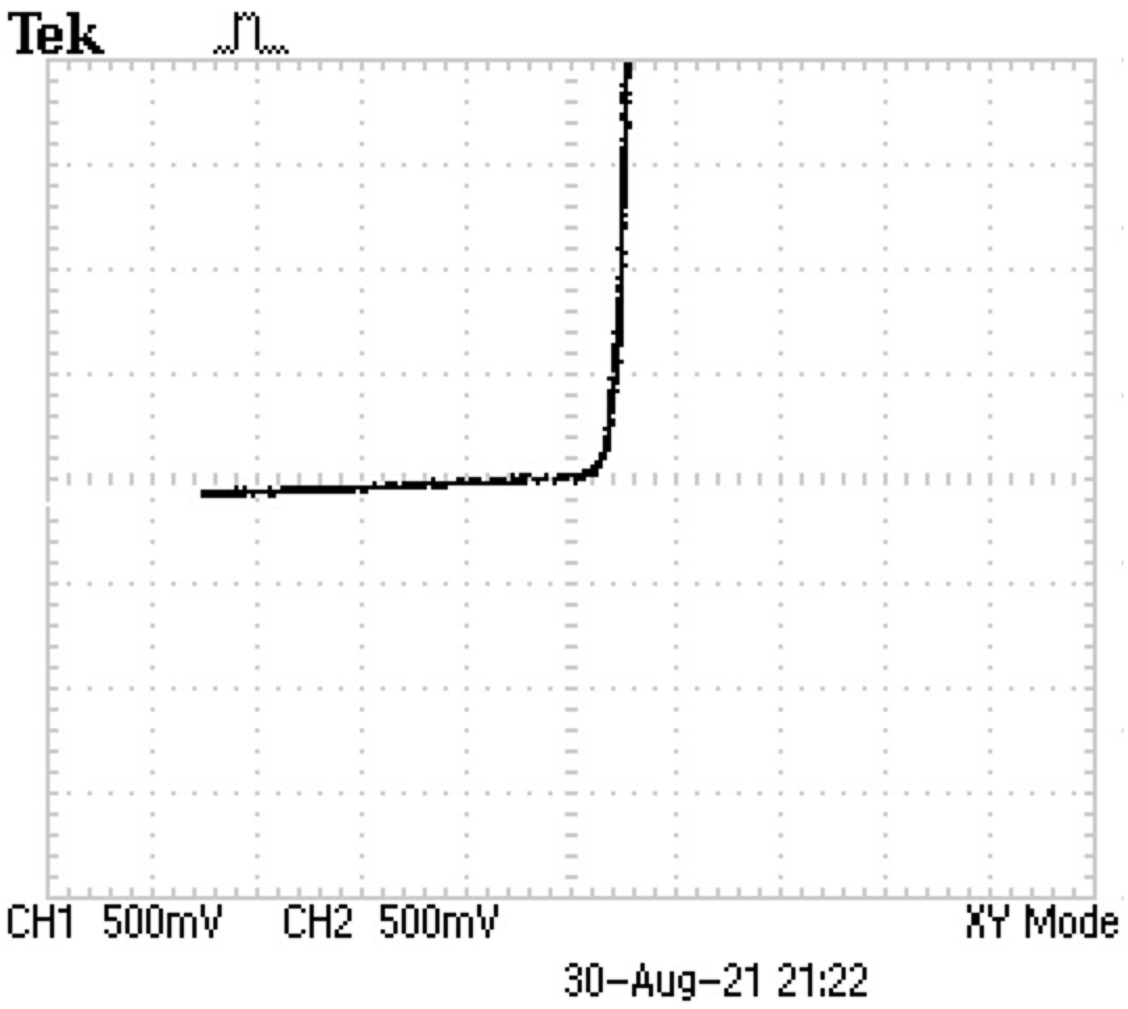


Zener 3.6 V, 1 kHz

Application 2 – I-V Characteristics of Silicon and Ge Diodes

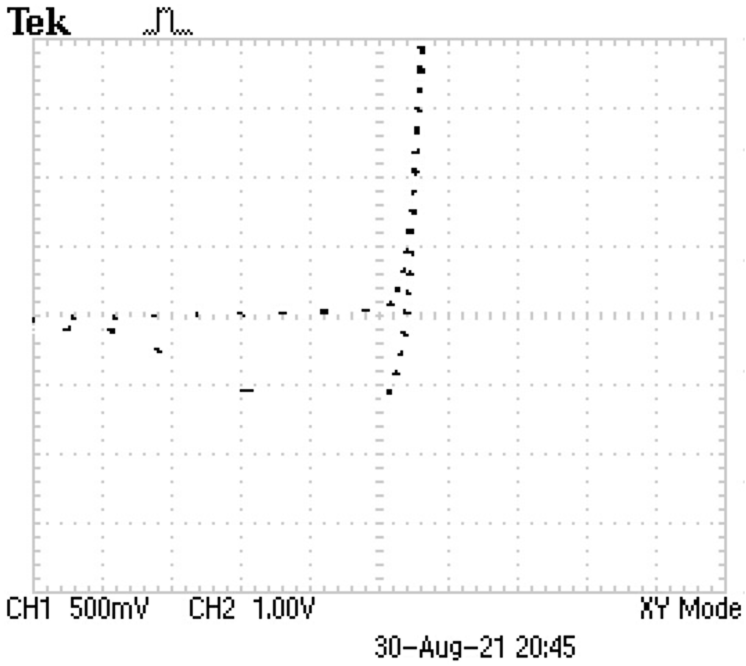


IN914 – Signal diode, 1 kHz

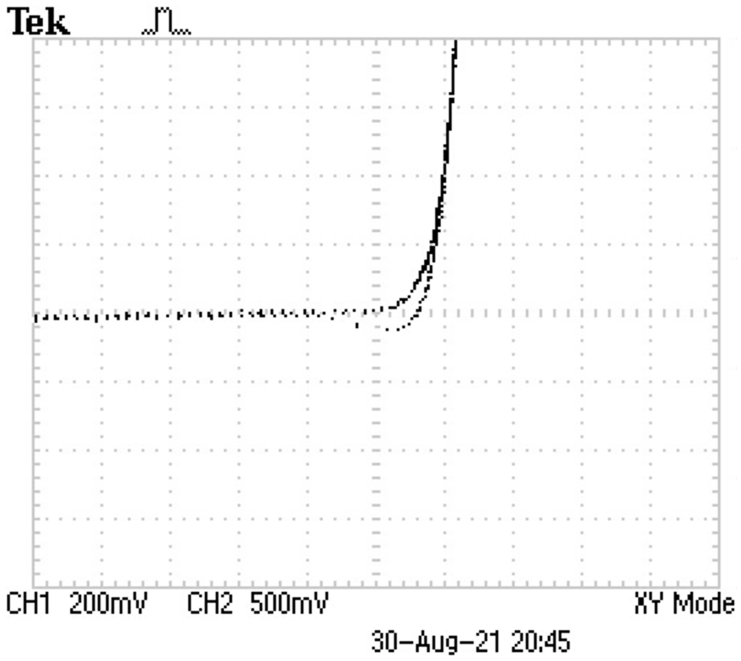


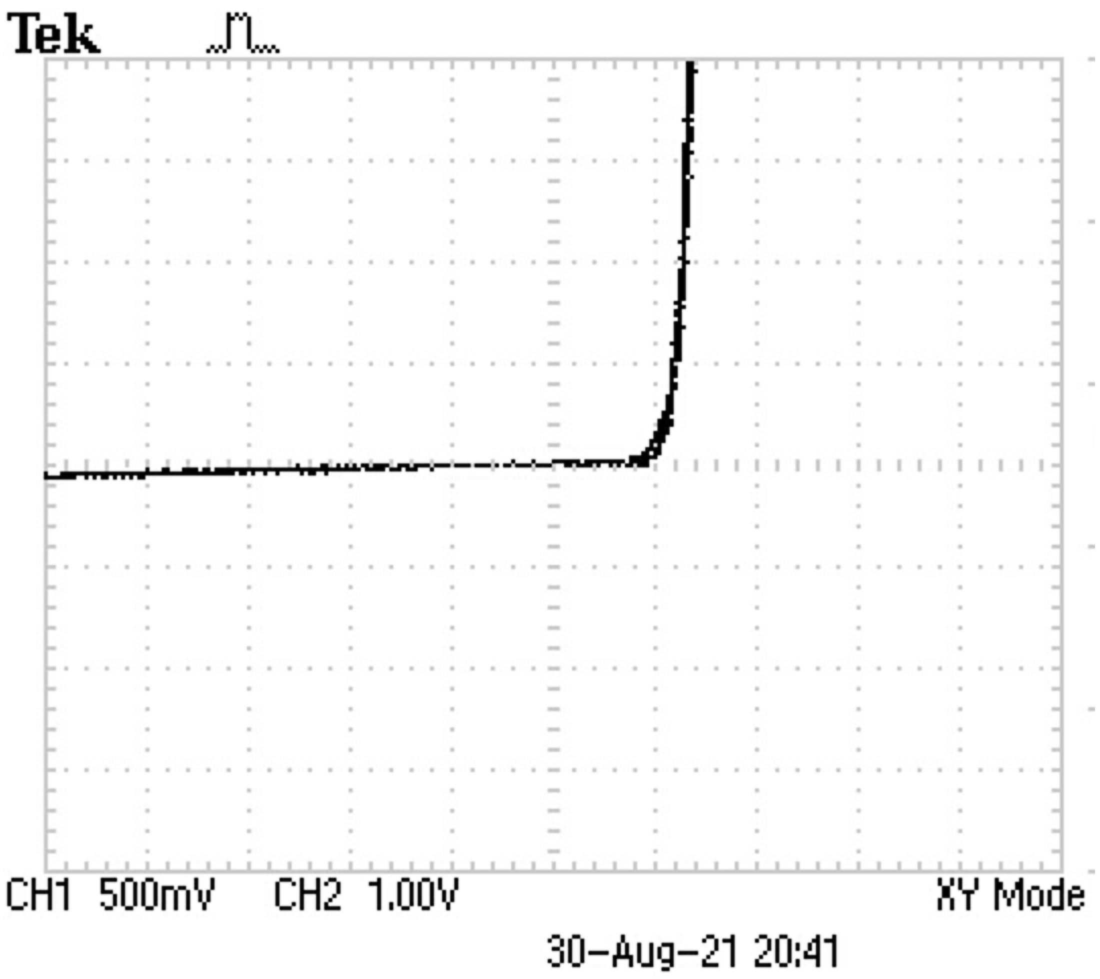
Ge diode, 100 Hz

10 kHz

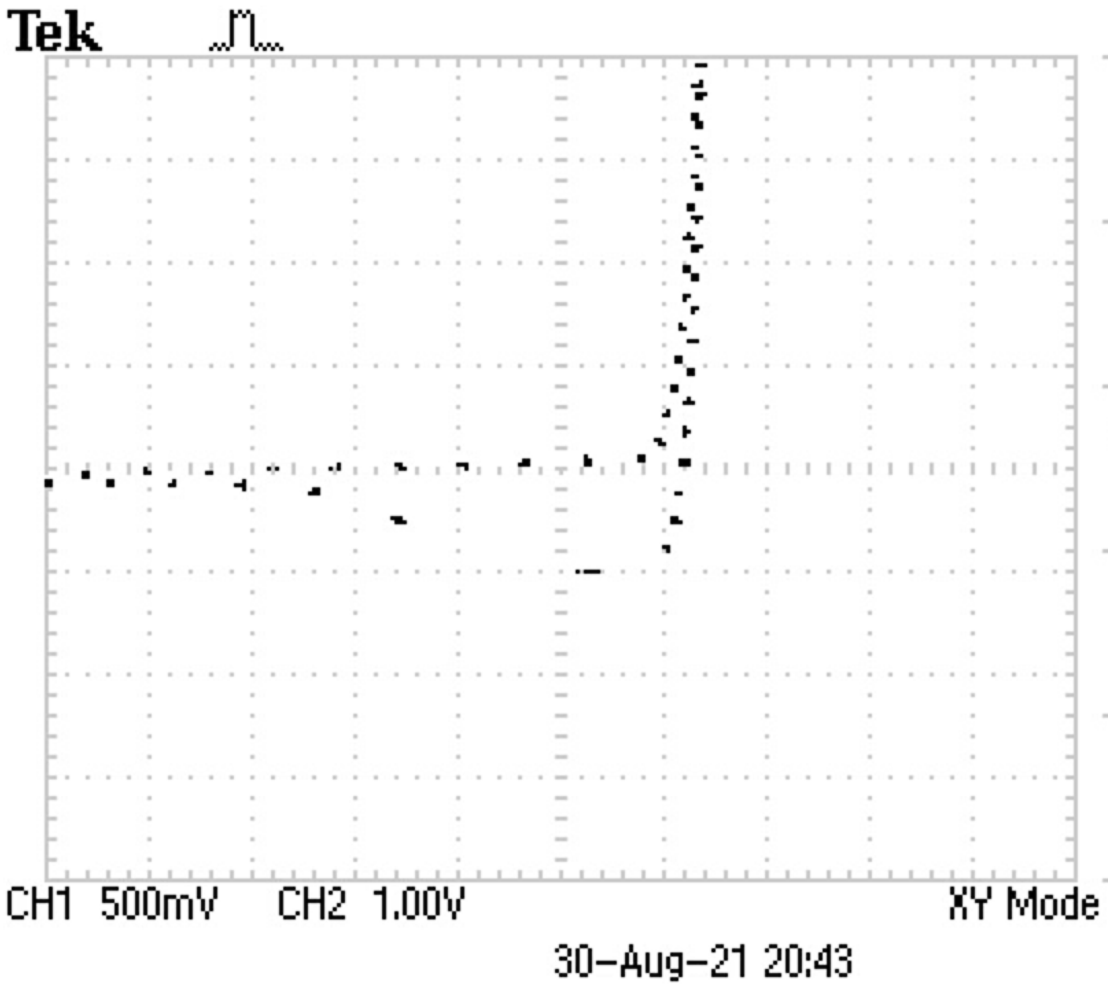


1 kHz



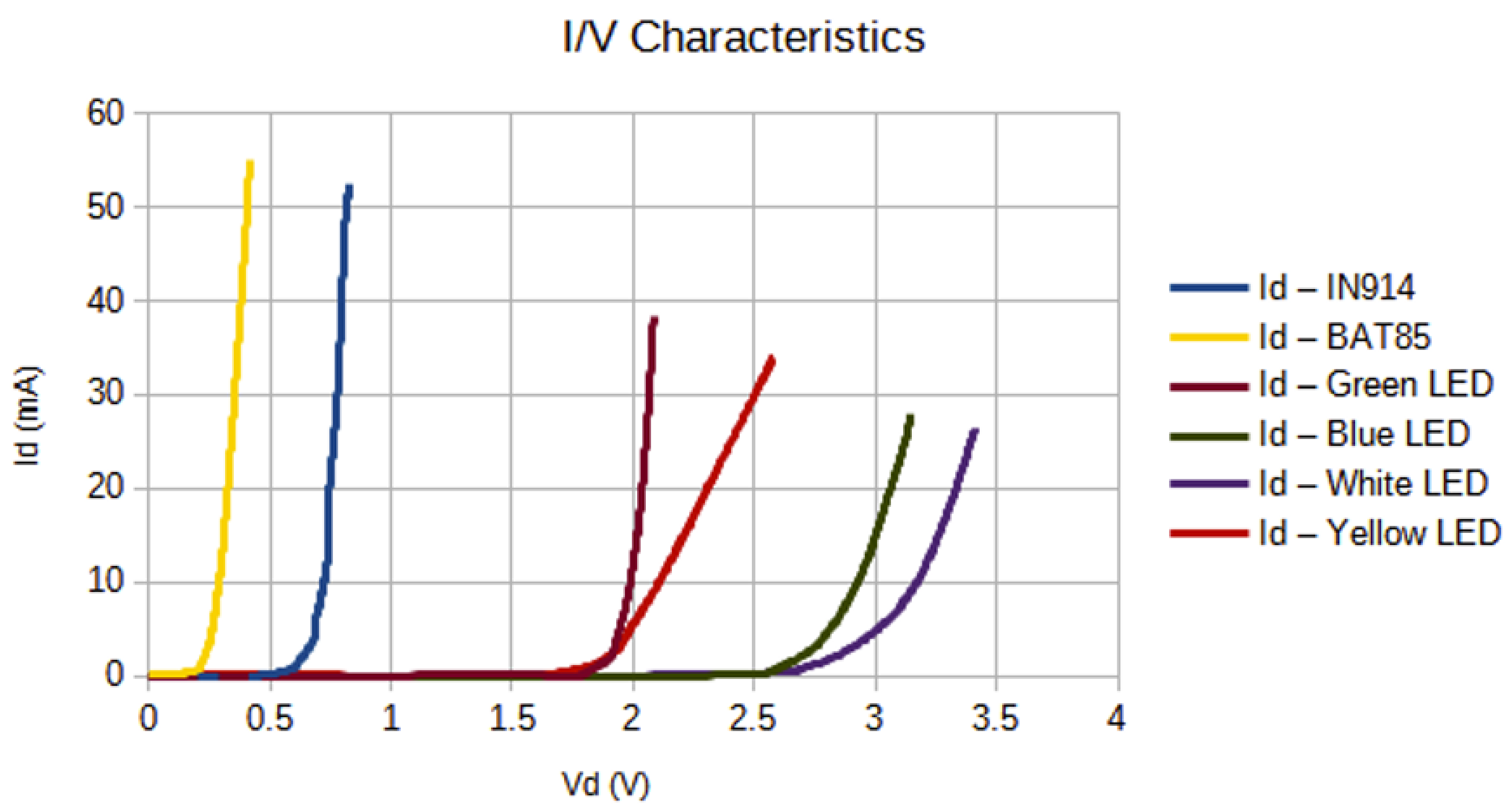


IN4007 1 kHz



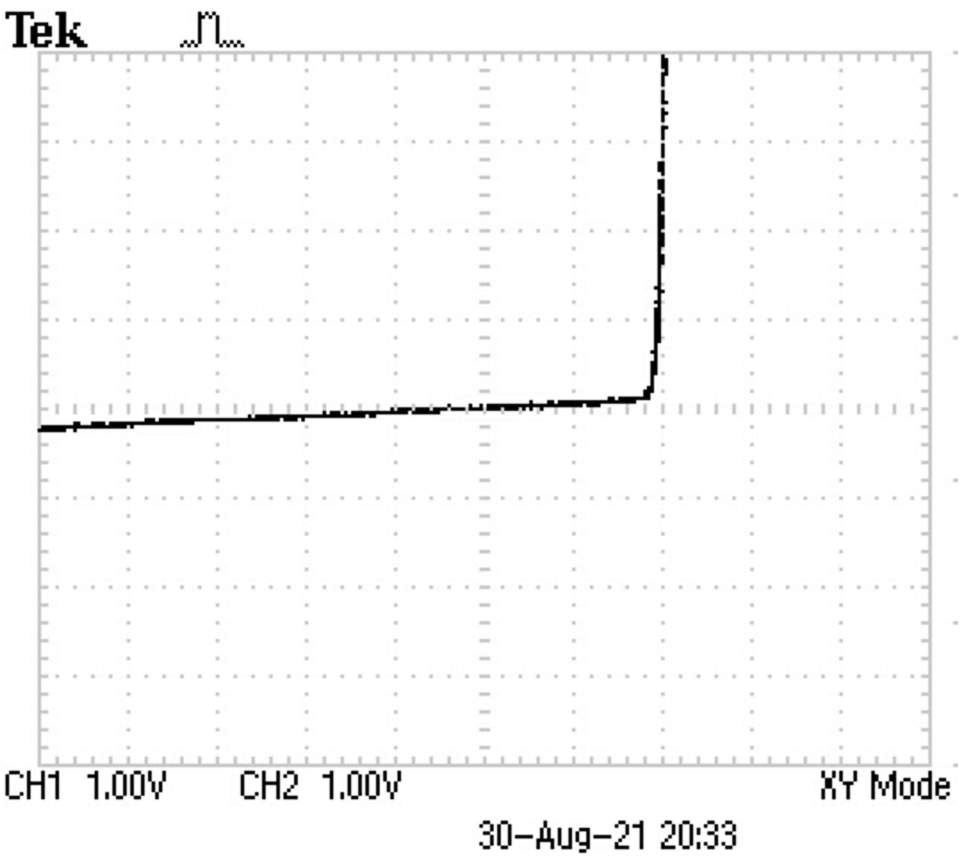
IN4007 10 kHz

Application 3 – I-V Characteristics of LEDs

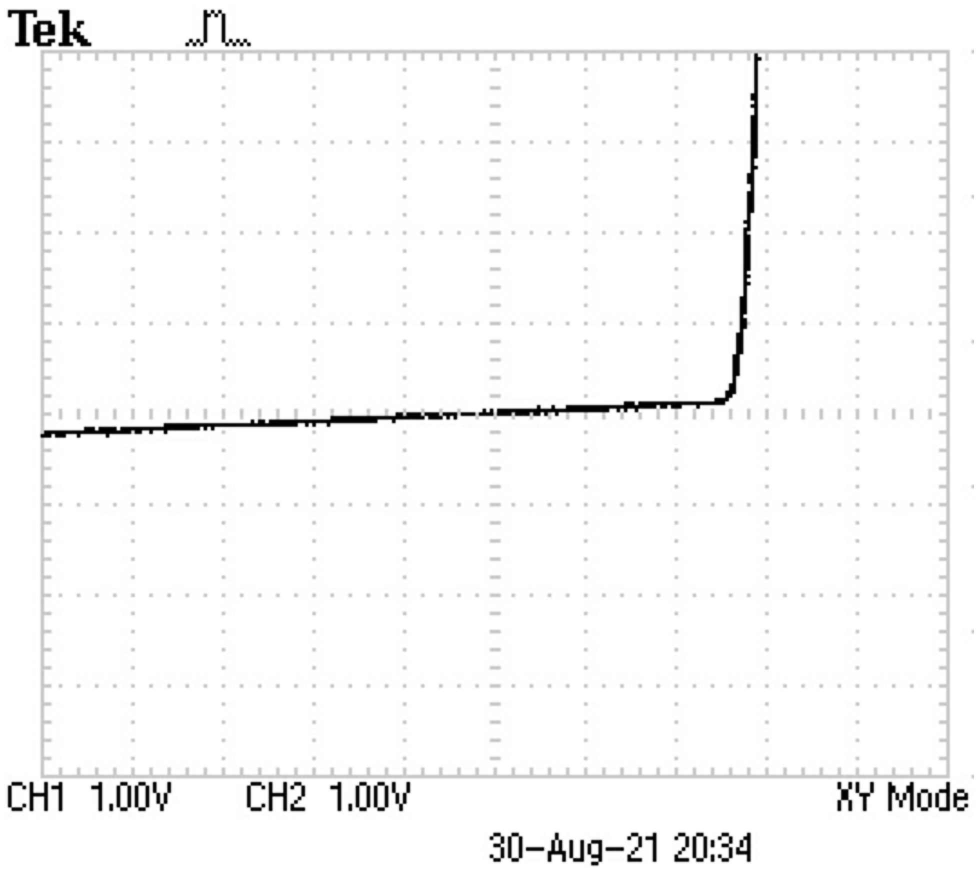


Measured in WEL Lab using a newly developed Data Acq Board

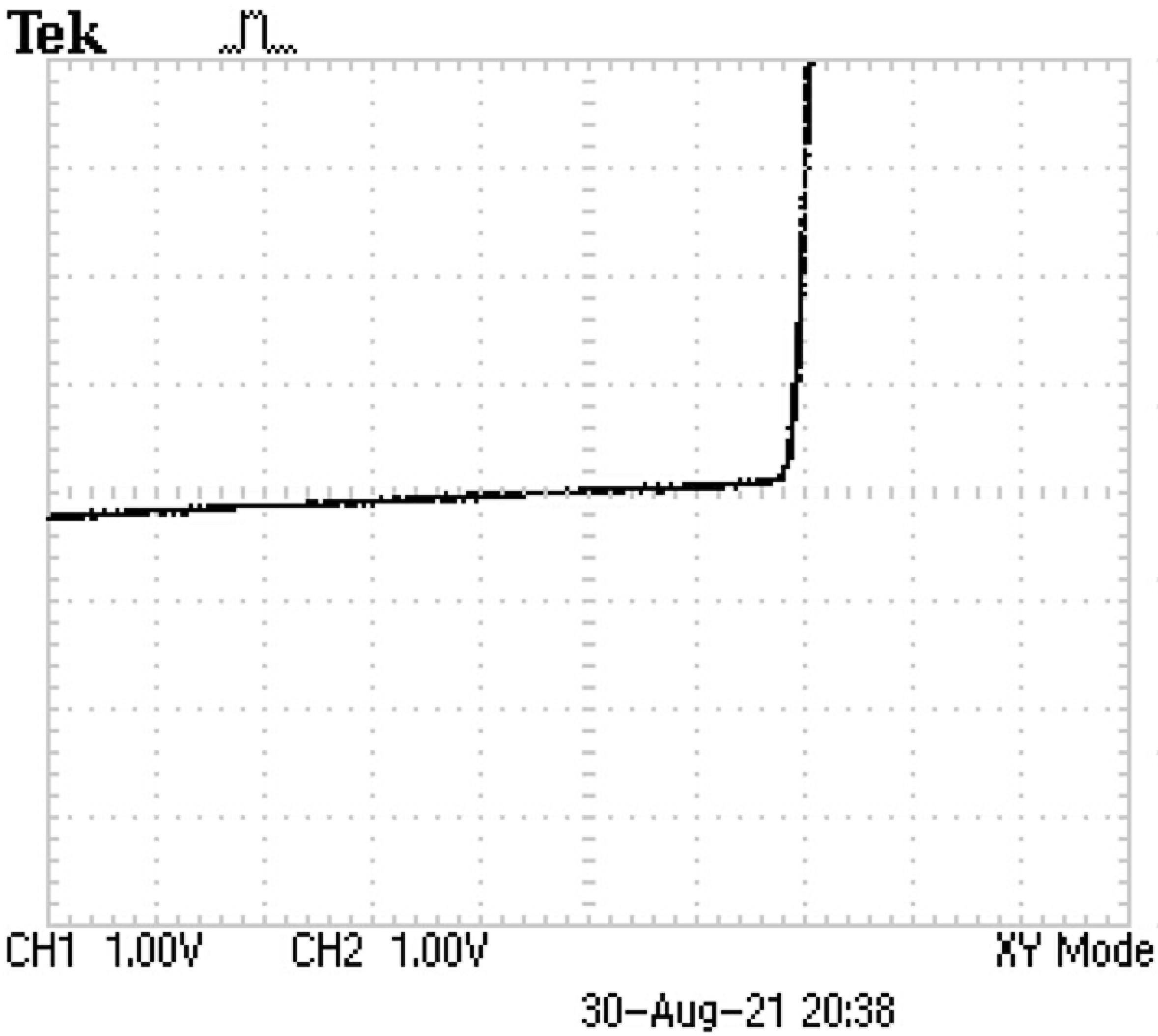
I-V Characteristics of LEDs – measured using our Difference Amplifier



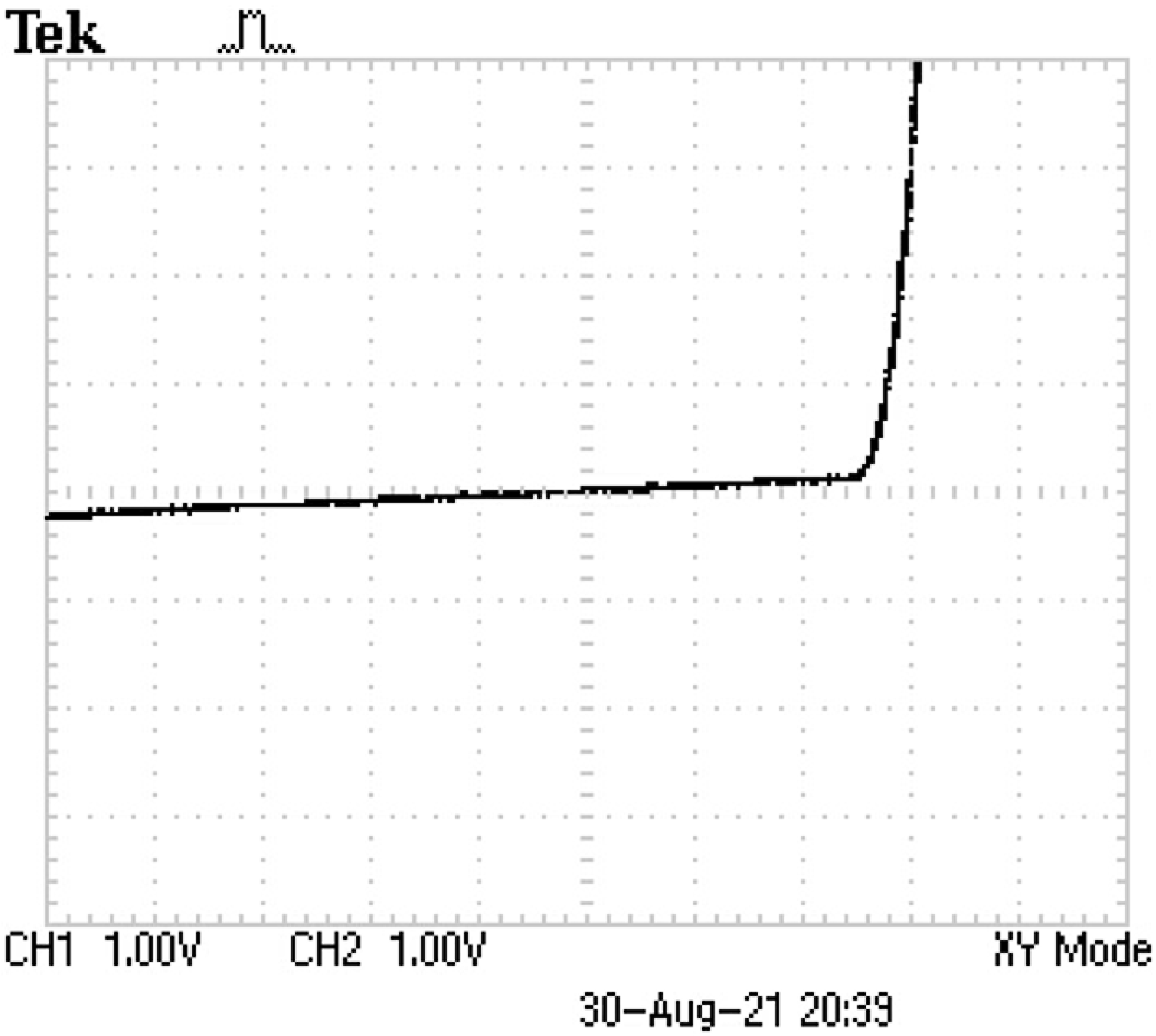
Green LED (1.8 V), 1 kHz



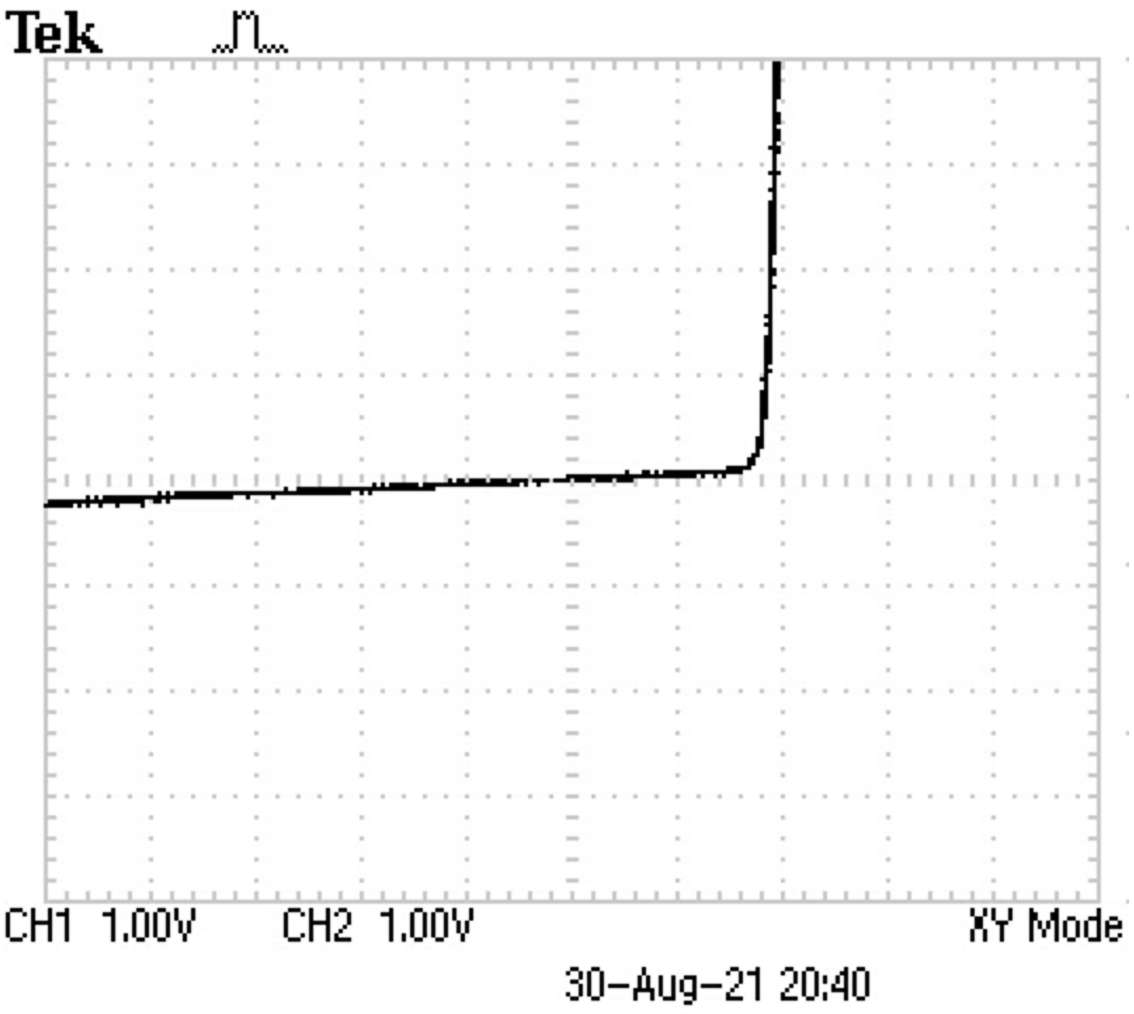
Blue LED (2.6 V), 1 kHz



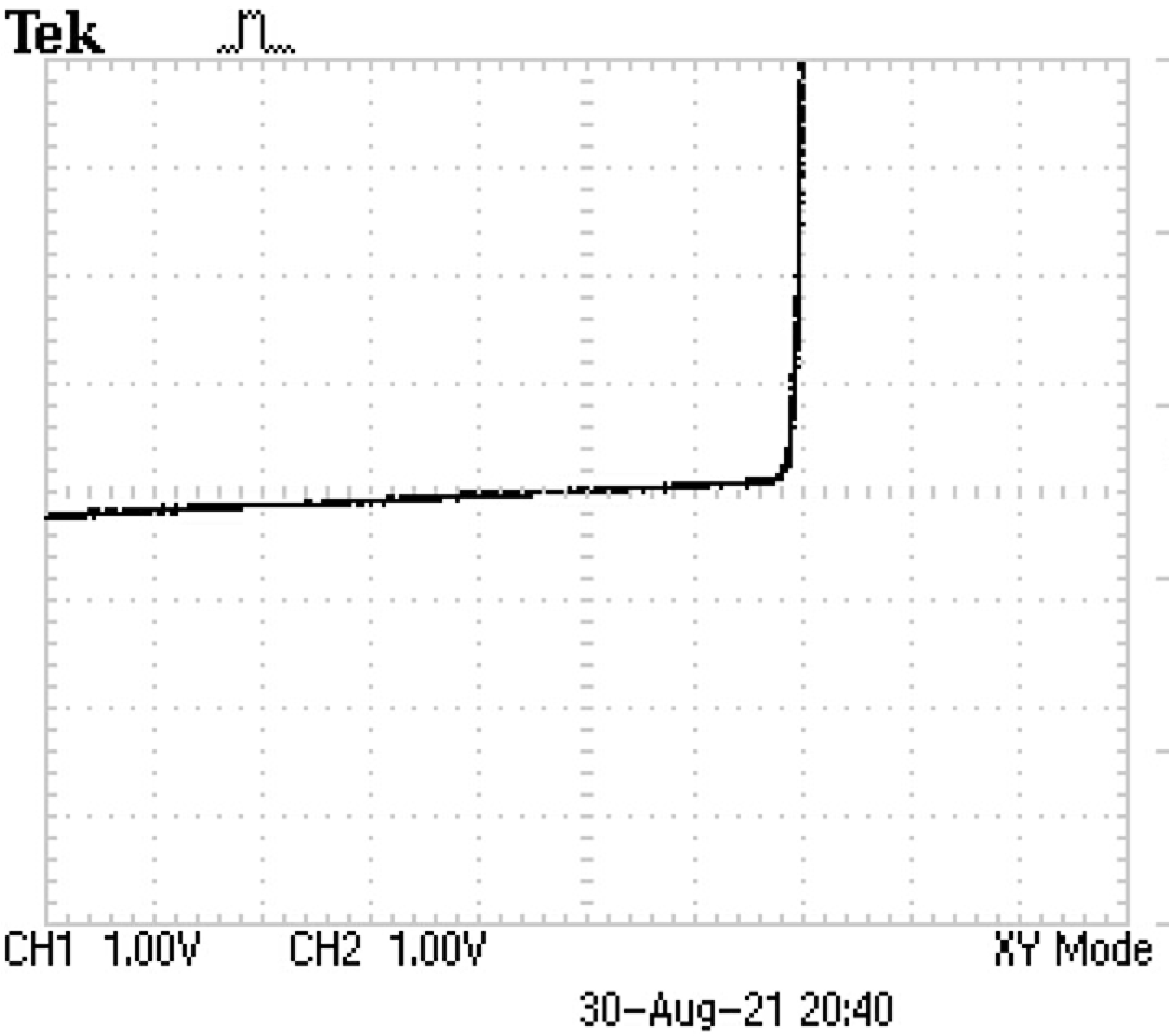
White LED (1.8 V), 1 kHz



White LED (2.6 V), 1 kHz



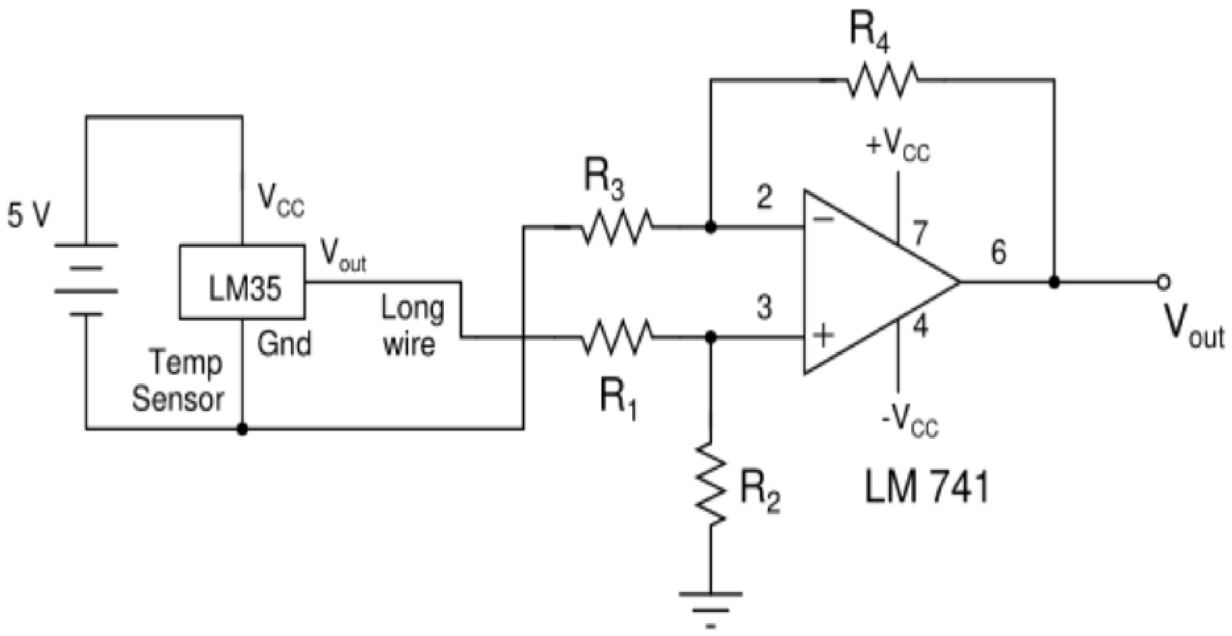
Red LED (1.8 V), 1 kHz



Yellow LED (1.9 V), 1 kHz

Interfacing LM35

Interfacing Circuit 3: Difference Amplifier (with $A_d = 10$)



- Problem of noise
- Difference amplifier preferred
- No conclusive results

Announcements

- Midsem Exam – Sep 24 (Friday) – 2:00 – 3:15pm (Weightage 18%)
  - Expts 1 to 6
  - SAFE/Codetantra
- No Quiz on Sep 24 Fri
- Quiz 7 and Quiz 8 on Oct 1 Friday

Quiz instructions

- Mobile Calculators NOT allowed
- No formula sheets
- Video Proctoring – Full view of your workspace