*==========One_OPAmp_Current_Source==========

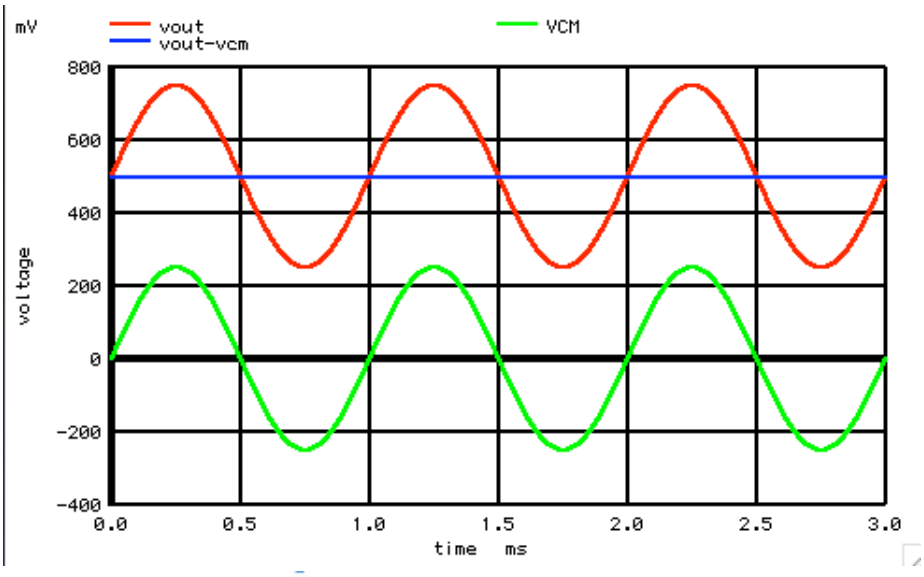
One common application for a Class D output stage is to drive LEDs. But using Class D output stages that use feedback create some stability challenges. The following example shows how feedback is used to create a one Op Amp current source.

```
=====================================================================
One_OpAmp_Current_Source
*
*                    R1A       INN        R1B
*     ______________/\  /\  /\___________/\  /\  /\_________
*   _|_              \/  \/    |           \/  \/          |
*  /V1 \                       | |\                        |
*  \___/                       |_|-\                  V4   |
*   _|_                          |  \_____________________|
*   ///                     INP  |  /                      |
*                              __|+/                       |
*              V3              | |/ OPA                    |
*         R1C          R3A     |                VOUT    R3B |
*     _/\  /\  /\__/\  /\  /\__|__/\  /\  /\___/\  /\  /\_|
*     |  \/  \/      \/  \/     R1D\/  \/    |   \/  \/
*     |      VC1         VCB                 |
*    _|_                 ______              |
*   /V2 \              _|_     |             |
*   \___/             /_  \    |          RL |
*    _|_             //\  \VCM|___/\  /\  /\_|
*    ///             \   \//        \/  \/
*                     \___/
*                      _|_
*                      ///
*
*.OPTIONS GMIN=1f       METHOD=trap   ABSTOL=1u     TEMP=27   srcsteps = 1  gminsteps = 1
*.OPTIONS RELTOL=.001   ABSTOL=1n     VNTOL=1u      ITL4=500  ITL1=400
*=========Create_Signal==================
VCM       VCM    0      DC     0      SIN(   0     .25    1k      )
V1        V1     0      DC     1
V2        V2     0      DC     2
B_OPA     V4     0      V =    5*tanh(tanh((V(INP)-V(INN))*30)*30)
R1A       V1     INN    1K
R1B       INN    V4     1K
R1C       V2     V3     1K
R1D       INP    VOUT   1K
R3A       V3     INP    2K
R3B       VOUT   V4     2K
RL        VOUT   VCM    1K
.control
*TRAN     TSTEP  TSTOP  TSTART TMAX   ?UIC?
tran      .1u    3m     0      .1u
set       pensize = 2
plot      vout VCM  vout-vcm
.endc
.end
```

==========

The Op Amp is simulated using the tanH function. Applying an AC sine-wave to voltage source VCM shows that the feedback from VOUT will hold the current through RL constant.

==========



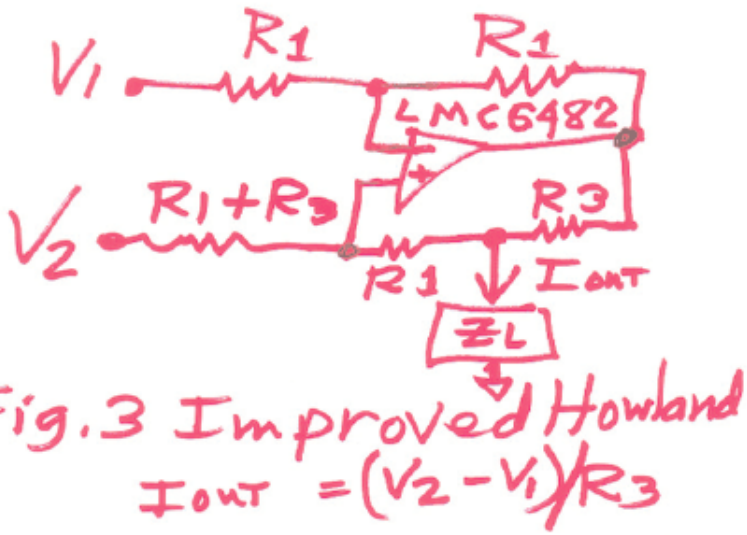


Fig.3 Improved Howland

$I_{OUT} = (V_2 - V_1)/R_3$

This circuit was stolen from Bob Pease. Thank Bob!

```
===========Full_Netlist_For_Copy_Paste=======================
One_OpAmp_Current_Source
*
*                    R1A      INN        R1B
*     _____________/\  /\  /\___________/\  /\  /\________
*   _|_              \/  \/    |          \/  \/          |
*  /V1 \                       | |\                       |
*  \___/                       |_|-\                  V4   |
*   _|_                         |  \_____________________|
*   ///                    INP  |  /                       |
*                              __|+/                       |
*               V3             | |/ OPA                    |
*         R1C         R3A      |           VOUT    R3B    |
*     _/\  /\  /\__/\  /\  /\__|__/\  /\  /\___/\  /\  /\_|
*     |  \/  \/      \/  \/      R1D\/  \/    |   \/  \/
*     |      VC1         VCB                  |
*    _|_                 ______               |
*   /V2 \              _|_     |              |
*   \___/             /_  \    |          RL  |
*    _|_             //  \  \VCM|___/\  /\  /\_|
*    ///             \   \//         \/  \/
*                     \___/
*                      _|_
*                      ///
*
*.OPTIONS GMIN=1f       METHOD=trap   ABSTOL=1u     TEMP=27   srcsteps = 1  gminsteps = 1
*.OPTIONS RELTOL=.001   ABSTOL=1n     VNTOL=1u      ITL4=500  ITL1=400
*=========Create_Signal==================
VCM       VCM    0      DC     0      SIN(   0     .25    1k      )
V1        V1     0      DC     1
V2        V2     0      DC     2
B_OPA     V4     0      V =    5*tanh(tanh((V(INP)-V(INN))*30)*30)
R1A       V1     INN    1K
R1B       INN    V4     1K
R1C       V2     V3     1K
R1D       INP    VOUT   1K
R3A       V3     INP    2K
R3B       VOUT   V4     2K
RL        VOUT   VCM    1K

.control
*TRAN     TSTEP  TSTOP  TSTART TMAX   ?UIC?
tran      .1u    3m     0      .1u
set       pensize = 2
plot      vout VCM  vout-vcm
.endc

.end

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```