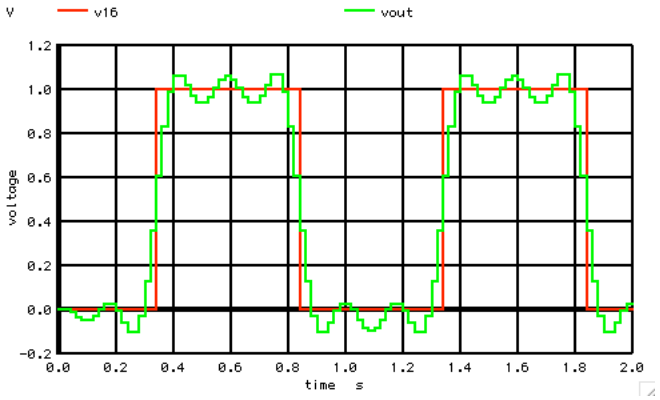
====FIR_brickwall_SquareWave_DC_Controlled====

FIR_brickwall

```
*                    V1        V2
*  ____    _____    _____    _____
*  |VIN|__|1/z |____|1/z |____|1/z |_....
*  |___|  |____|    |____|    |____|
*                 __|__    __|__
*                |  a1 |  |  a2 |        NORMAL FIR FORMAT
*                |_____|  |_____|
*                    |        |
*                    |        |___\ /_ \
*                    |            // \  \____|OUT|
*                    |____________\\ /_  /    |___|
*                                 / \___/
*.............................................................
*
*          F1        F2        F3        F4
*          __|__ V1  __|__ V2  __|__ V3  __|__  V4
*  ____   |_____|   |_____|   |_____|   |_____|
*  |VIN|__|D_LAY|___|D_LAY|__|D_LAY|___|D_LAY|_...
*  |___|  |_____|   |_____|   |_____|   |_____|
*            |         |         |         |...
*            |         |
*                      |              DC VOLTAGE CONTROLED FORMAT
*        _/\  /\  /\_|_|VOUT|
*       |  \/  \/      |____|
*      7/7   R1 = 1 Ohms
*
```

The sanity check for this FIR digital filter is how it responds to a square wave. The response should match what happens when a square wave is brickwalled filtered using FFT methods.



The output should resemble the square wave in terms of its fundamental and all its harmonics where in this case any harmonic above the 5th has been removed. Equally important is that none of the remaining harmonics should have any shift in time or phase compared to the fundamental. From the point of view of the 16th delay point, this is how things appear to be.

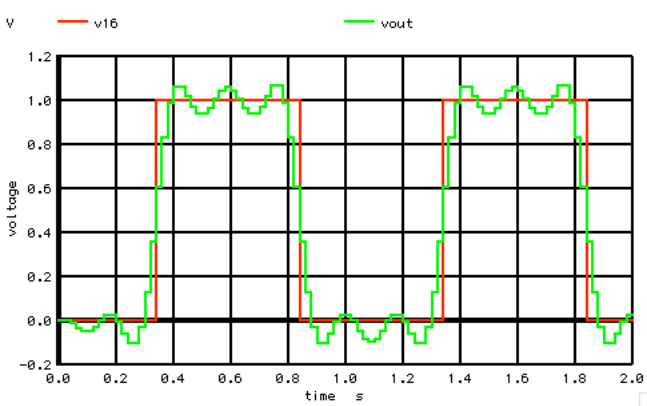
```
*=========Input_Signals=========================================
*V_PULSE   NODE_P NODE_N DC     VALUE  PULSE( VINIT  VPULSE TDELAY TRISE  TFALL  PWIDTH PERIOD )
VIN        VIN    0      DC     0      PULSE( 0      1      10u    10u    10u     .5    1 )
VT         VT     0      DC     0      PWL(   0      0      100    100)
VFIN       FIN    0      DC     1
VFC        FC     0      DC     1
VFS        FS     0      DC     50
BVCLK      CLK    0      V      =  u(sin(6.283*V(FS)*V(VT)))
BF12       F12A   0      V      =  2*sin(3.14*V(FC)/V(FS))
```

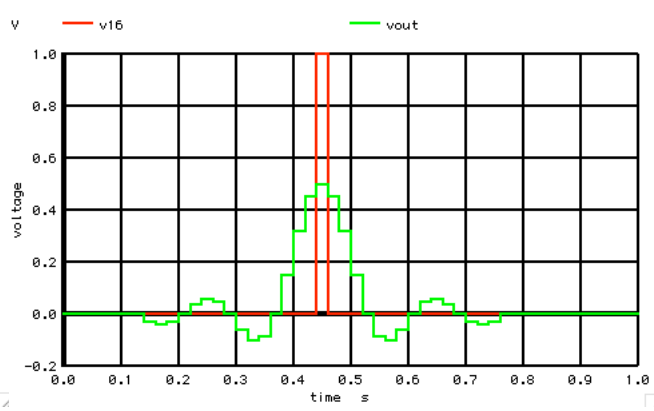
The impulse has been converted to a square wave.

```
*=========SCALED_DELAY==========================================
XZ_DLAY    VIN    VINZ   CLK                 Z_DLAY
XS_DLAY1   VINZ   V1     VOUT   CLK   F17   S_DLAY
XS_DLAY2   V1     V2     VOUT   CLK   F16   S_DLAY
XS_DLAY3   V2     V3     VOUT   CLK   F15   S_DLAY
XS_DLAY4   V3     V4     VOUT   CLK   F14   S_DLAY
XS_DLAY5   V4     V5     VOUT   CLK   F13   S_DLAY
XS_DLAY6   V5     V6     VOUT   CLK   F12   S_DLAY
XS_DLAY7   V6     V7     VOUT   CLK   F11   S_DLAY
XS_DLAY8   V7     V8     VOUT   CLK   F10   S_DLAY
XS_DLAY9   V8     V9     VOUT   CLK   F9    S_DLAY
XS_DLAY10  V9     V10    VOUT   CLK   F8    S_DLAY
XS_DLAY11  V10    V11    VOUT   CLK   F7    S_DLAY
XS_DLAY12  V11    V12    VOUT   CLK   F6    S_DLAY
XS_DLAY13  V12    V13    VOUT   CLK   F5    S_DLAY
XS_DLAY14  V13    V14    VOUT   CLK   F4    S_DLAY
XS_DLAY15  V14    V15    VOUT   CLK   F3    S_DLAY
XS_DLAY16  V15    V16    VOUT   CLK   F2    S_DLAY
XS_DLAY17  V16    V17    VOUT   CLK   F3    S_DLAY
XS_DLAY18  V17    V18    VOUT   CLK   F4    S_DLAY
XS_DLAY19  V18    V19    VOUT   CLK   F5    S_DLAY
XS_DLAY20  V19    V20    VOUT   CLK   F6    S_DLAY
XS_DLAY21  V20    V21    VOUT   CLK   F7    S_DLAY
XS_DLAY22  V21    V22    VOUT   CLK   F8    S_DLAY
XS_DLAY23  V22    V23    VOUT   CLK   F9    S_DLAY
XS_DLAY24  V23    V24    VOUT   CLK   F10   S_DLAY
XS_DLAY25  V24    V25    VOUT   CLK   F11   S_DLAY
XS_DLAY26  V25    V26    VOUT   CLK   F12   S_DLAY
XS_DLAY27  V26    V27    VOUT   CLK   F13   S_DLAY
XS_DLAY28  V27    V28    VOUT   CLK   F14   S_DLAY
XS_DLAY29  V28    V29    VOUT   CLK   F15   S_DLAY
XS_DLAY30  V29    V30    VOUT   CLK   F16   S_DLAY
XS_DLAY31  V30    V31    VOUT   CLK   F17   S_DLAY
VF1        F1     0      DC     0
VF2        F2     0      DC     +1.000
VF3        F3     0      DC     +0.900
VF4        F4     0      DC     +0.640
VF5        F5     0      DC     +0.300
VF6        F6     0      DC     +0.000
VF7        F7     0      DC     -0.175
VF8        F8     0      DC     -0.207
VF9        F9     0      DC     -0.125
VF10       F10    0      DC     +0.000
VF11       F11    0      DC     +0.096
VF12       F12    0      DC     +0.118
VF13       F13    0      DC     +0.075
VF14       F14    0      DC     +0.000
VF15       F15    0      DC     -0.060
VF16       F16    0      DC     -0.080
VF17       F17    0      DC     -0.060

*TRAN      TSTEP  TSTOP  TSTART TMAX   ?UIC?
.tran      30u    1      0      30u    UIC
.control
run
set        pensize = 2
plot       v16    vout
.endc
```

Simulate the same. The square wave response and impulse response are shown together.





Add enough delay elements, and the square way response will approach perfection.

```
*
*          F1        F2        F3        F4
*          __|__ V1  __|__ V2  __|__ V3  __|__   V4
*|VIN|__|D_LAY|___|D_LAY|__|D_LAY|___|D_LAY|_...
*|___|  |_____|   |_____|  |_____|   |_____|
*
*          |_________|_________|_________|...
*
*                    |
*                                  DC VOLTAGE CONTROLED FORMAT
*        _/\   /\   /\_|_|VOUT|
*      _|_   \/   \/      |____|
*     ///    R1 = 1 Ohms
```

==========Full_Netlist_For_Copy_Paste==========

```
FIR_brickwall_Square
*
* |VIN|__|1/z|____|1/z|____|1/z|_....
*  |___|  |___|    |___|    |___|
*              __|__     __|__
*             |a1|      |a2|        NORMAL FIR FORMAT
*             |__|      |__|
*                |         |
*                |         |___\ /___\
*                |            // \   \____|OUT|
*                |___________\\ /_  /     |___|
*                            / \___/
*.............................................................
*

*         F1        F2        F3        F4
*        __|__ V1  __|__ V2  __|__ V3  __|__  V4
*|VIN|__|D_LAY|___|D_LAY|__|D_LAY|___|D_LAY|_...
*|___|  |_____|   |_____|  |_____|   |_____|
*          |_________|________|_________|
*                    |
*                    |____|VOUT|
*       _/\  /\  /\_|_|____|
*     _|_  \/  \/
*     ///   R1 = 1 Ohm
*


*=========Create_Signal==================
*V_PULSE  NODE_P NODE_N DC     VALUE  PULSE( VINIT  VPULSE TDELAY TRISE  TFALL  PWIDTH PERIOD )
VIN       VIN    0      DC     0      PULSE( 0      1      10u    10u    10u     .5    1 )
VT        VT     0      DC     0      PWL(   0      0      100    100)
VFIN      FIN    0      DC     1
VFC       FC     0      DC     1
VFS       FS     0      DC     50

BVCLK     CLK    0      V      =  u(sin(6.283*V(FS)*V(VT)))
BF12      F12A   0      V      =  2*sin(3.14*V(FC)/V(FS))

VF1       F1     0      DC     0
VF2       F2     0      DC     +1.000
VF3       F3     0      DC     +0.900
VF4       F4     0      DC     +0.640
VF5       F5     0      DC     +0.300
VF6       F6     0      DC     +0.000
VF7       F7     0      DC     -0.175
VF8       F8     0      DC     -0.207
VF9       F9     0      DC     -0.125
VF10      F10    0      DC     +0.000
VF11      F11    0      DC     +0.096
VF12      F12    0      DC     +0.118
VF13      F13    0      DC     +0.075
VF14      F14    0      DC     +0.000
VF15      F15    0      DC     -0.060
VF16      F16    0      DC     -0.080
VF17      F17    0      DC     -0.060

XZ_DLAY   VIN    VINZ   CLK              Z_DLAY
XS_DLAY1  VINZ   V1     VOUT   CLK  F17   S_DLAY
XS_DLAY2  V1     V2     VOUT   CLK  F16   S_DLAY
XS_DLAY3  V2     V3     VOUT   CLK  F15   S_DLAY
XS_DLAY4  V3     V4     VOUT   CLK  F14   S_DLAY
XS_DLAY5  V4     V5     VOUT   CLK  F13   S_DLAY
XS_DLAY6  V5     V6     VOUT   CLK  F12   S_DLAY
XS_DLAY7  V6     V7     VOUT   CLK  F11   S_DLAY
XS_DLAY8  V7     V8     VOUT   CLK  F10   S_DLAY
XS_DLAY9  V8     V9     VOUT   CLK  F9    S_DLAY
XS_DLAY10 V9     V10    VOUT   CLK  F8    S_DLAY
XS_DLAY11 V10    V11    VOUT   CLK  F7    S_DLAY
XS_DLAY12 V11    V12    VOUT   CLK  F6    S_DLAY
XS_DLAY13 V12    V13    VOUT   CLK  F5    S_DLAY
XS_DLAY14 V13    V14    VOUT   CLK  F4    S_DLAY
XS_DLAY15 V14    V15    VOUT   CLK  F3    S_DLAY
XS_DLAY16 V15    V16    VOUT   CLK  F2    S_DLAY
XS_DLAY17 V16    V17    VOUT   CLK  F3    S_DLAY
XS_DLAY18 V17    V18    VOUT   CLK  F4    S_DLAY
XS_DLAY19 V18    V19    VOUT   CLK  F5    S_DLAY
XS_DLAY20 V19    V20    VOUT   CLK  F6    S_DLAY
XS_DLAY21 V20    V21    VOUT   CLK  F7    S_DLAY
XS_DLAY22 V21    V22    VOUT   CLK  F8    S_DLAY
XS_DLAY23 V22    V23    VOUT   CLK  F9    S_DLAY
XS_DLAY24 V23    V24    VOUT   CLK  F10   S_DLAY
XS_DLAY25 V24    V25    VOUT   CLK  F11   S_DLAY
XS_DLAY26 V25    V26    VOUT   CLK  F12   S_DLAY
XS_DLAY27 V26    V27    VOUT   CLK  F13   S_DLAY
XS_DLAY28 V27    V28    VOUT   CLK  F14   S_DLAY
XS_DLAY29 V28    V29    VOUT   CLK  F15   S_DLAY
XS_DLAY30 V29    V30    VOUT   CLK  F16   S_DLAY
XS_DLAY31 V30    V31    VOUT   CLK  F17   S_DLAY

R1        VOUT   0      .25

.tran     30u    2      0      30u    UIC

.control
run
*TRAN     TSTEP  TSTOP  TSTART TMAX   ?UIC?
*tran      10u    2      0      10u
```

```
set       pensize = 2
plot      v16 vout

.endc
*=========Switch_Model==========================================

.MODEL    SW      SW(    VT=.5 VH=.1  RON=100m ROFF=100MEG)

*=========SCALED_DELAY==========================================
*            CLK
*
*              __|__
*  ____      ____      ____________      ____
*  |VIN|____|D_LAY|____________|VOUT|
*  |___|    |_____|   |        |____|
*                      |     | F1
*                      |  |\  V
*                      |_|1\/\/\___|____|
*                         |  /\/\/
*                         |/
*

.SUBCKT   S_DLAY VIN    VOUT  IOUT  CLK  F1
 XZ_DLAY  VIN    VOUT   CLK  Z_DLAY
 BOUT     IOUT   0      I  = -V(VOUT)*V(F1)
.ENDS     S_DLAY


*=========Z_DLAY========================================
*
*                                 ___________________|
*                                |  ____________     |  ____
*  ____    |\          VBF       |_|\_\____\        |_|____\
*  |CLK|__|1\_____________|_/ VLP     |NE \_|  PE \_
*  |___|  |/  |/\  /\  /\_____|___|  2 /|  |___|  3  /|
*              \/  \/  _|_      /___/  |      |___/  |
*             RLP      ___                            |
*                      |
*                 CLP 7//
*
*  ____    |\  V1  /   V2        |\  V3  /   V4      |\
*  |IN |__|4\____/_____________|5\____/_____________|6\_|OUT|
*  |___|  | / S1  NE   | _|_    | / S2  PE   | _|_  | /  |___|
*         |/            |  ___  |/            |  ___ |/
*        Rshunt1        |  |C1  Rshunt2       |  |C2
*       _/\  /\  /\__   |_|_   _/\  /\  /\__   |_|_
*     |_  \/  \/      7// |_  \/  \/      7//
*    7//                  7//
.SUBCKT   Z_DLAY VIN    OUT    CLK
 B1       VBF    0      V =    u( v(CLK )-.5 )
 RLP      VBF    VLP    10k
 CLP      VLP    0      50n    IC=0
 BNOR2    NE     0      V =    1-u( u(v(VBF )-.5)+u(.5 -v(VLP ) ) -.1)
 BAND3    PE     0      V =      u( u(v(VBF )-.5)*u(.5 -v(VLP ) ) -.1)
 B4       V1     0      V =    V(VIN)
 S1       V1     V2     NE     0    SW
 R1       V2     0      100Meg
 C1       V2     0      1u
 B5       V3     0      V =    V(V2)
 S2       V3     V4     PE     0    SW
 R2       V4     0      100Meg
 C2       V4     0      100u
 B6       OUT    0      V =    V(V4)
.ENDS     Z_DLAY

.end
```

6.7.11_12.16PM
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