Scope Probes

By G8MNY   (Update Apr 09)
(8 Bit ASCII Graphics use code page 437 or 850)

They come in a few standard forms..

1:1 COAX

A terminated teed coax is the only way get the highest bandwidth into your scope. Simple nothing to adjust!

```
                                   BNC T   SCOPE INPUT LOAD
Input  o)===============================┬─o)──────────┬──┬─────Scope
75/50Û >┘       75/50Û coax        75/50Û │  ¸25pF=== 1M  Attenuators
                                   Term └──┴───────────┴──┴─────& Amp
```

The scope input capacitance has the minimum effect on the signal.
Only usable on DC-RF 75/50Û circuits, e.g. DC-200MHz.
Voltage limited to scope input/termination load rating.
Able to see low signal levels, no added calibration errors.

1:1 TEST LEAD

These are straight screened wires like a coax, with just test clips on the ends & BNC at the scope end. Simple nothing to adjust!

```
                                          SCOPE INPUT LOAD
Input  >─)================================o)──────────┬──┬─────Scope
1MÛ+   >─┘     200pF of lead Capacitance    │ ¸25pF=== 1M  Attenuators
225pF            e.g. 75Û coax              └──────────┴──┴─────& Amp
```

     Coax capacitance per foot is about 20/30pF for 75/50Û.

The capacitance depends on coax impedance & lead length. Only usable on DC AF & low Z circuits where the loading is not important e.g. DC-3MHz (just about OK on terminated 75Û video!)
Voltage limited to scope input.
Able to see low signal levels.

1:1 PROBE

These have one of the 2 sizes of standard probe systems. The spring hook can changed to a long probe, just the tip or tip covers for small point or IC leg work, or be adapted to a BNC plug.
Simple nothing to adjust!

```
    PROBE PARTS
 Spring Hook      Ì  Tip   Probe                  Coax
  _________/~~~~~~Ì   _┌─────────||~~~~~~|── |~'──┐___\\ ___┌──'~| ──|   |'~~||
c_\________|      Ì  ─┤_│         ||      ||  |   │~~~~ \\~~└──._| ||  |   |  ||
           \______Ì    └─────────||______|── |_.──┘                  ──|___|.__||
                  Ì            .─.__  Screw or            Screw or
                               │ │ _│  Crimp                 Crimp      BNC
 Long Probe       Ì ┌─BNC_┐   │ │  │
  _________/~~~~~~Ì └─────┘   │_│──┘
▄▄\________|      Ì      _     ¦ Earth
           \______Ì  /~ │Tip   Ì Clip
                  Ì  \_ │Shroud ¦
                       ~        Ì
Input  Probe parts                                 SCOPE INPUT LOAD
Load   --┬─L┬L─)============================─33─o)──────────┬──┬─────Scope
1MÛ+     ┤├┤   │  70pF Low capacity 3m lead └─────│ ¸25pF=== 1M  Attenuators
100pF  >───────┘ 300Û DC, Z = 500Û, (7pF/Ft)      └──────────┴──┴─────& Amp
```

The load capacitance depends on lead length (1.2, 1.5, 2, or 3m) & the coax type which here is a very fine single strand core polly foam insulated high impedance type. There is often a tweak on the probe (tuned circuit + L shown & a series scope R) to improve HF & pulse performance.

Only usable on DC AF & low Z circuits where the loading is not important.
e.g. DC up to 6-10MHz on 75Û terminated systems.
Voltage limited by probe & scope. Able to see low signal levels.

10:1 TRIMMED PROBE
These are the most common probe, with in built attenuator reducing input load.
Must be calibrated before use on that scope/input!
Not able to see very low signal levels.

```
    PROBE PARTS
 Spring Hook      Ì  Tip   Probe                  Coax
  _________/~~~~~~Ì   _┌───────||~~~~~~~|── |~'──┐___\\ ___┌──'~| ──|   |-'~~||
c_\________|      Ì ─┤_│       ||  0 Adj||  |    │        │    | || |   |    ||
           \______Ì    └───────||_______|── |_.─┘~~~~ \\~~└──._| ──|___|-.__||
                  Ì
```

```
Input  Probe parts
Load        ┌┤├┐C Adj *                       SCOPE INPUT LOAD
10MÛ+ ─47─L┴9M┴)============================o)────────┬──┬────Scope
15pF  >─────────┘   70pF Low capacity 3m lead  │ ¸25pF=== 1M  Attenuators
                        Z = 500Û               └────────┴──┴────& Amp
```

The accurate series 9MÛ gives the 10:1 DC calibration with the scope input R. The trimmer C in the probe has to be exactly 1/9 of the total capacitance of the scope & lead, then the probe's frequency & phase (pulse) response will be flat. So the probe is designed for a particular lead! Note the more complex tiny probe components are to improve bandwidth & pulse response.

Usable DC-60MHz (3.5nS rise time). Voltage limited by probe design/10x scope input. Some older larger 10:1 probes (e.g. Tektronix) use an adjustable moving capacitance tube & have a much higher rated voltage & are useful for mains & SMPS & line output work, where the peak pulse voltages can be over 1kV @ 50kHz, which most of the smaller probes CAN NOT safely handle! See the rating curve for your probe...

```
Peak Volts
 700┤
 600┤────────┐    Typical Probe Derating Curve
 500┤        Ì
 400┤         ¦  This means that you can't scope HF Tx aerial!
 300┤          \
 200┤           '·.,__
 100┤                 ~~''───----....,,_______
   0┼────┼────┼────┼────┼────┼────┼────┼────┼────>Hz
    0   50k  100k 200k 500k  1M   2M   5M  10M
```

1:1/10:1 SWITCHED PROBE
These are also common, with a built in switched attenuator reducing input loading on 10:1. & the 1:1 option for seeing small signals, but note the loading changes when switching.
On 10:1 mode, it must be calibrated before use on that scope/input!

```
    PROBE PARTS
 Spring Hook      Ì  Tip  Probe  Adj  SW          Coax                ___
  _________/~~~~~~Ì  _┌─────────┐||~~~~~~~~|── |~'──┐___\\ ___┌──'~| ──|   ├'~~||
c_\________|      Ì ─┤_│         │|| 0   _■ |││ |   │          │    | ││|   ││  ||
           \______Ì  └─────────┘||________|── |_.──┘~~~~ \\~~└──._| ──|___├.__||
                  Ì                1:1:10

Input  Probe parts
Load     ┤├──┐C Adj *                        SCOPE INPUT LOAD
10MÛ+ ─47┼9M─┼)============================o)─────────┬──┬─────Scope
15pF     |_\_||  55pF Low capacity 2m lead  │ ¸25pF=== 1M  Attenuators
or 1M >──────┘         Z = 500Û             └─────────┴──┴─────& Amp
+80pF
```

Usable up to 6-10MHz @ 1:1, & 60MHz @ 10:1. Voltage limited by probe & switch design/10x scope input or scope input @ 1:1. Due to the added switch & risk to the scope I would not use this type on any high voltage like mains or SMPSU testing!

10:1 TRIMMED SCOPE END
These are the less common, with a fixed probe capacitor, the trimmer is put at the scope end. As it is the scope input capacitance that varies scope input to scope input, this approach lets the probe maker better match the components (e.g. series Ls & Rs etc) to get a better frequency/pulse response, however the probe tip capacitance is a little bit higher!
Must be calibrated before use on that scope/input!
Not able to see very low signal levels.

```
    PROBE PARTS
 Spring Hook      Ì  Tip   Probe                   Coax           ┌─────┐    BNC
  _________/~~~~~~Ì  _┌─────────┐||~~~~~~|── |~'──┐___\\ ___┌──'~| ──|     ├'~~||
c_\________|      Ì ─┤_│         │||      |││ |   │          │    | │││  0  ││  ||
           \______Ì  └─────────┘||______|── |_.──┘~~~~ \\~~└──._| ──| Adj ├.__||
                  Ì                                              └─────┘
Input  Probe parts
Load     ┤├Fixed C                              SCOPE INPUT
10MÛ+ ─47┴9M┴)==============================┬──o)─────────┬──┬─────Scope
15pF  >──────┘  70pF Low capacity 3m lead  └─┤├ ¸25pF=== 1M  Attenuator
                    Z = 500Û          *Trimmer └─────────┴──┴─────& Amp
```

The accurate series 9MÛ gives the 10:1 DC calibration with the scope input R. The fixed C in the probe has to be exactly 1/9 of the total input capacitance & the scope end *trimmer is adjusted for this.

probe design/10x scope input, this may be higher than the probe end trimmer type.

100:1 TRIMMED PROBE
Same as above but are less common, usually scope end trimmed allowing for high voltage with the larger in built attenuator reducing input loading by 100, useful on sensitive large signal DC or where higher capacity probe can't be used, if there is enough signal!
No good for low signal levels!

```
Input  Probe parts
Load     ┤├─┐Fixed C                               SCOPE INPUT LOAD
100MÛ ─47┘99M┘)==============================┬─o)────────┬──┬────Scope
+4pF  >────────┘ 70pF Low capacity 3m lead   === │ ¸25pF=== 1M  Attenuators
                      Z =  500Û          Trim└─────────┴──┴───& Amp
```

The accurate series 99MÛ gives the 100:1 DC calibration with the scope input R.
The high voltage C in the probe has to be exactly 1/99 of the total input
capacitance for the probe to be flat.

Usable DC-60MHz. Voltage limited to by probe design/100x scope input e.g. 1.5kV
Even so some are not rated for SMPSU work see derating curve above, where the
peak spike voltages may be 1kV @ 50kHz!

10:1 SCOPE & PROBE TRIMMED
These are far less common, with a trimmer capacitor & presets. They give the
best performance & must be calibrated before use on that scope/input!
Not able to see very low signal levels.

```
    PROBE PARTS
Spring Hook       Ì  Tip   Probe              Coax                      BNC
    ________/~~~~~~Ì   _┌──────┐||~~~~~~|── |~'──┐__\\ __┌──'~| ──┌───────┐-'~~||
  c_\_______|      Ì ─┤_│      │|| 0 Adj||| │    ┘        └──┘ | ||│ 0 0 0 ││    ||
            \______Ì    └──────┘||______|── |_.──┘~~~ \\~└──._| ──│  Adj  │-.__||
                   Ì                                              └───────┘
```

```
Input  Probe parts                           3 HF
Load     ┤├C trimmer 1kHz              preset Rs   SCOPE INPUT
10MÛ+ ─47┘9M┘)============================─R1┬─────o)────────┬──┬────Scope
16pF  >────────┘ 35pF Low capacity 1.5m lead   ├R2─┤├─┤  ¸25pF=== 1M  Attenuator
                    Z = 500Û                 R3          │   │  & Amp
                                             ├─L─┤├──────┴───┴───
                                             └─47┘
```

Usable DC-300MHz where the loading is not important. Voltage limited to by
probe design/10x scope input. The probe trimmer affects 1kHz & the 3 scope end
presets all affect different HF frequencies allowing good calibration on square
wave harmonics to over 300MHz & a pulse rise time of 1.4nS.

AP BNCs

```
This a surrounding locking             ░░░░
pin system that tells the      ──┌───┐-'~~||
scope you have a 1:10 probe    ||│   ││   ||BNC
fitted, for on screen          ──└───┘-.__||
calibration information etc.           ░░░░██PIN
```

PROBE PARTS INTERCHANGEABILITY
Various makers often use similar parts, but not always! E.g. Tip threads can be
different, & also the tip length & diameter making it incompatible to some
makes of probes hooks.

Screw on leads are also made in slightly different ways & may no be compatible!

CALIBRATING A SCOPE PROBE *
Connect the probe to the scope 1kHz square wave calibrator & set the input,
trigger & timebase range to show a large square wave. Then using the insulated
tool provided adjust the trimmer...

```
     TO LITTLE HF             CORRECT               TO MUCH HF
      ____         _      ______       __      |`\.___
  ,/'    |     ,/'       |      |      |       |      |      |    | = faint
  |      |     |         |      |      |       |      |      |    | Verticals
  |      |     |         |      |      |       |      |      |
  |      `\.___|         |      |______|       |      |   ___|
                                                      |./'
```

With a 2 (or more) trimmer probe a higher frequency test square wave of 1MHz will be needed for the scope end trimmer(s). Adjust the trimmers in much the same way, endeavouring to get the best square "corner pulse" shape possible.

FAULTY SCOPE ATTENUATOR
If the wave shape changes (other than height) as the scope input attenuator is changed, then the scope attenuator needs recalibrating, as the input capacity (& hence the probe response) should not change if the scope is set up OK!

PROBE FAILURE
Tips: These can brake the screw in tip off as there is huge leverage with the whole probe on the end, but you can get spares with probes.

Hooks: The hook sleeve will melt if left on components while soldering! The hooks also break, (made of wire or metal strip) due to the leverage factor.

```
 _  _________________________┌────┐
(/_/           |\\Spring\\\|▒|    |  -=Probe
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~/└────┘    Top
                        Solder
```

I have made long lasting replacement hooked strips from scrap junior hacksaw blades cut into strips & filled out the hook shape. A good solder (try ally solder) & key filing are needed to attached!

Body: These fail due to broken internal wires to the socket, & also fractured PCB. The assembly can be difficult to take apart. but all the plastic covers are push fit. A broken multiplying R is usually fatal, unless you want a 1:1 probe! Be careful not to lose the red tweaker cover when sliding the hand cover off. Switched versions need extra care!

```
          Plastic covered     _  Handle pulls off >
          metal probe tube   |‾└───----..,..
Screw        _______________┌─────────────┐ __ Tight push fit socket
on tip -<|- [  heatshrink covered PCB -[▒[■
             ~~~~~~~~~~~~~~~└─────────────┘ ~~\Lead connector screw thread
         Earth contact ring/|_┌──''''~~~~~
                                         ^ Keyway
```

Note some probes use a metal plated plastic body are not metal at all!

Leads: These fail:- a) broken intermittent inner of very thin (hair gauge) lose single core as it will not stretch, b) the push on crimped outer connectors. these have just a centre pin to make connection to the movable inner wire. Repairing by shorting the lead by much my uncalibrated it!

Bnc: If moulded on type little can be done. Box type these can fail due to movement of the plug/socket wires to the PCB & although fiddle are easily repaired.

PROBE PICKUP/HUM LOOPS
With different earth potentials & high capacity from mains filters to chassis it is quite normal to see unwanted signals on a sensitive range on the scope. This not helped by long resistive scope leads, so 1st try a thick bonding lead from the scope earth point to the work (NO LIVE chassis use isolation transformer).

```
                                    ┌───────┐
                                    │ Scope │
             ____                   │       │
            │Work <─────────────────┤Y      │
            │    │                  │       │
            │____│================  │_______│
Mains earth ──┘     HUM DIFFERENCE      └─────Mains Earth
                     SHORTED OUT
```

Differential mode can be useful to, where you use both scope inputs to see the difference..

```
                                    ┌────────┐
                                    │  Scope │
             ____                   │        │
            │Work <─────────────────┤Y1\ Diff│
            │    ┌<─────────────────┤Y2/ Mode│
            │____│                  │________│
Mains earth ──┘     HUM DIFFERENCE       └─────Mains Earth
```

For HF noise try the ferrite ring trick on the mains or scope probe lead & see the common mode noise disappear.

```
                                                 ┌───────┐
                                                 │ Scope │
 ___________              ____                   │       │
│   Mains   │  2 core    │Work <─────((((────────┤Y      │
│ Isolation │=mains lead=│    │─┘     ====       │       │
│Transformer│            │____│      Ferrite     │_______│
~~~~~~~~~~~~~         HF noisy PSU                    └─────Mains Earth
```

Why Don't U send an interesting Bul?

73 De G8MNY @ GB7CIP