Notes on the use of

Special PBG5 pulser
Serial No. J00*****

26th June 2001

Caution

Special PBG5 Pulser Serial No. J00*****

This equipment is a research tool that has been intentionally designed to generate short high energy electromagnetic pulses and the EM emissions will be highly sensitive to the load applied by the user. It is suitable for use only in a sealed electromagnetic or laboratory environment, unless it is used in a system that has been verified by the system builder to comply with EC directive 89/336/EEC. It will interfere with sensitive equipment in the local environment.

With an appropriate load, the unit is safe for use by an educated user in a laboratory environment. You are warned however that the radiation from the system with an antenna or inappropriate load attached can damage sensitive equipment and corrupt data stored in computer and microprocessor based systems including aeronautical and other safety critical systems. It can cause terminal failure of vital medical electronic systems such as pacemakers. This equipment is supplied on the understanding that the user will analyse these risks, accept responsibility for them and take appropriate precautions in the use of this instrument.

The output from this pulse generator will destroy most types of power attenuators and electronic test equipment. It is the users responsibility to ensure that any apparatus connected to the output is suitably rated.

Kentech Instruments Ltd accepts no responsibility for any damage or liabilities incurred in the operation of this equipment.

The Output Unit contains 120W of 4kV power supplies, this can cause death or injury from burns and electric shock.

Do not remove covers! Return to Kentech for servicing.

When fitting the output connector ensure that all four fixing screws are tightened to maintain a low impedance ground connection and that the plastic insulating collar and sprung centre contact are fitted.

Use

The PBG5 is a state of the art avalanche pulser utilising a series parallel array of 21 avalanche stacks coupled with various transformers to generate a large output amplitude of ≥24kV into 50Ω.

The instrument consists of two 19" modules, the 3U Trigger Unit (TU) containing the microprocessor and low voltage trigger electronics and the 6U Output Unit (OU) housing all the avalanche stacks and their power supplies. They are designed to be stacked with the TU uppermost in a 19" rack system. The ac power for the OU must be taken from the TU using the IEC male/female lead supplied, and the external ac power (110 to 240V 50 or 60Hz, approx 250W) should be applied to the TU. The front panel switch will therefore switch power to both modules. The equipment must be grounded via the power connector to maintain protection from electric shock.

There is a fuse in the IEC power input socket on the rear of the Trigger Unit and a further fuse on the rear panel of the Output Unit. Both fuses should be 5A.

At maximum repetition rate the air cooled OU will dissipate approximately 250W of thermal power, consequently it requires an adequate and unobstructed flow of clean air.

RF emission from the circuitry inside the OU is severe, the module relies upon the integrity of its enclosure to contain the radiation. Further, because of the high power and high frequency requirements the OU uses its chassis as ground return. Therefore it is important for correct operation that all screws and fasteners remain secure.

The OU is controlled and tested by the microprocessor in the TU by means of the Control and Monitor links on rear panels. The two control connectors and the two monitor connectors must be linked together with the D type leads supplied. The leads are simple 1 to 1 connections with a screen.

The trigger signal can be generated internally or applied externally to the TU. When external triggering is used, the trigger signal should be ≥5 volts into 50Ω with a fast rising edge (<5ns) to maintain the low jitter of the system. Do not trigger the generator at a

rate in excess of 1kHz. The external trigger input is a BNC connector mounted on the front panel. When the TU is triggered the "triggered" LED on the front panel will flash. The trigger input for the OU must be taken from the trigger output of the TU using the short BNC to BNC cable provided. There is an additional "triggered" LED on the OU showing the state of the trigger stack.

In the internal trigger, single shot and delayed modes there is an internal delay which may be adjusted by the user. Another front panel BNC connector "pre-trigger output" provides a signal of ~10V into 50Ω. This is approximately synchronous with the trigger, in advance of the high voltage pulse output and may be used to trigger auxiliary equipment such as a sampling oscilloscope. There are thermal drifts in the delay generator which will stabilise after the pulser has been switched on for ~20 minutes.

In "direct" mode the external trigger signal is applied directly to the avalanche stack and the low level circuitry is bypassed to give the minimum trigger delay. There is no monitor output generated in this mode.

The main output of the unit appears at the front panel connector which is a special connector of Kentech design. There are drawings of this connector at the rear of this manual to allow the user to manufacture additional units as required. The pulser will tolerate open circuit, short circuit and arc loads at the output connector for a very short time, after which insulator damage may occur to the connector. With a cable longer than 1m attached, the pulser should tolerate open circuit, short circuit and arc loads indefinitely. It is not necessary to have an matched 50Ω load to preserve pulser lifetime, but note that the pulser is not reverse terminated so reflections from the output may be a problem if the load is not 50Ω.

If it is necessary to monitor or characterise the pulse output then suitable attenuators must be used. **The >24kV pulse from this unit is capable of destroying most types of power attenuators and loads including most of the high pulse power types**. The pulser was characterised at the factory using two methods:-

a) Two x2 Kentech suicide T attenuators in series followed by two x10 Barth 142-NMFP-20 attenuators then two radial x10 attenuators. The unit will destroy the Barth 142 if only one T attenuators is used.

b) Attaching 10 parallel 50Ω cables to the output cable to form a 50 to 5Ω mismatch to reflect most of the power back to the pulser output, then monitoring the signal at the end of one of these 50Ω cables using two x10 Barth 142-NMFP-20 attenuators followed by two Radial x10 attenuators.

Method a) was used to obtain the photographs enclosed in this manual.

The output may be observed with a high bandwidth oscilloscope. This may either be a fast (>3GHz) single shot type or a sampling type.

If the output of the pulser is to be used directly or via any passive network it is essential that cable lengths are kept as short as possible and that only high quality cable is used. This will enable the fast rising edge generated by the unit to reach the load without serious degradation.

The PBG5 is controlled by the microprocessor unit with LCD display and four button keypad. On power up, the trigger input of the avalanche stack is disabled, note that it is always necessary to issue commands to the microprocessor unit via the keyboard or the RS232 interface to enable the trigger circuit and make the pulser run normally. Please see the software section below.

The µP unit includes a self test routine. This should be run at least once a day and at power up, and any faults noted. Otherwise there is no regular maintenance required. There is some redundancy in the unit by virtue of its design, and the unit may continue to operate at slightly reduced amplitude with several faults present. The switching elements in these avalanche pulsers generally have a long life, but their life is finite and therefore it is sensible to switch off the unit or at least not trigger it when it is not required. It is not possible to write a test routine to find 100% of all possible faults, so if the unit appears to malfunction, contact Kentech Instruments for advice.

IMPORTANT

When fitting the output connector ensure that:
i) all four fixing screws are tightened to maintain a low impedance ground connection
ii) the plastic insulating collar and sprung centre contact are fitted

This PBG5 has been modified to allow some fine adjustment of the amplitude in the range 60 to 100%. This can be done via the front panel keypad and LCD under the System Status menu, or remotely via the RS232 interface. Note that on power up the amplitude defaults to 100%.

PBG5 V1.0 Software

The microprocessor used is a Hitachi H8/532 running a FORTH operating system and it is programmed in the FORTH programming language. It is not necessary to have any knowledge of the H8 or FORTH to operate the pulser.

a) MAIN MENU

On power up or on entering LOCAL mode from remote, the unit will briefly display the "Kentech Instruments" banner and then the main menu "TEST RUN STATUS". The cursor will be under TEST as shown, press the left and right keys to select one of TEST or RUN or STATUS then press the down key to execute. In this menu the up key has no effect. While the main menu is displayed, the serial port is monitored. If the µP receives an ESC character (ASCII code = 27) it will enter REMOTE mode.

b) TEST

The display will show the "2kV pulses" warning message then stop and wait for the user to press a key. Press Up to abort the test and return to the main menu, Up/Yes to execute the test. Left and Right have no effect.

Each stack is powered up in turn. Its DC consumption of HT current is measured and checked to be within acceptable limits. Current too low indicates a failure of the HT supply, current too high indicates a number of short circuit switching elements. The maximum and minimum DC consumption is measured to ensure that the stack is not self triggering.

Finally a brief summary of the faults found is displayed, and the unit waits for the user to press a key. Press Down/No to return to the main menu, Up/Yes, Left and Right have no effect.

TEST maintains a log of the test results, these may be listed using a terminal connected to the RS232 interface - see below. The HT current consumption of each channel that was measured during final test at Kentech is stored in battery backed RAM, and this is printed out in brackets next to the value measured by TEST for a fast comparison.

Each channel has a FAULT flag which is reset at power up and on completion of a successful test and set if a test fails.

Note that the AC test of the output stacks will apply pulses of 2kV amplitude to the output.

c) RUN

The display will show the ">24kV pulses" warning message then stop and wait for the user to press a key. Press Down/No to abort the test and return to the main menu, Up/Yes to enter RUN mode.

The HT is switched on to each stack in turn.

Subsequently, the trigger is enabled, and the unit will now run normally while waiting for the user to press a key. Press Down/No to leave RUN mode, switch off HT, disable the trigger and return to the main menu.

d) STATUS

The unit will display the status "SYSTEM STACK" sub-menu. Press the Left and Right to select one of SYSTEM or STACK then press the Up/Yes to execute. Press Down/No key to return to the main menu.

e) SYSTEM STATUS

The total number of stacks with their FAULT flags set is displayed. Press Down/No to return to "SYSTEM STACK" sub-menu, Up/Yes to continue, Left and Right have no effect.

The total number of stacks with their ENABLE flags set is displayed. Press Down/No to return to "FAULT" display, Up/Yes to continue, Left and Right have no effect.

The AMPLITUDE setting is displayed. Press Down/No to return to "ENABLE" display, Up/Yes has no effect, Right to enter the AMPLITUDE editor. In the editor you can use Up/Yes, Down/No, Left and Right to change the amplitude, then press Left to exit.

f) STACK STATUS

The selected stack number is displayed. Press Down/No to return to “SYSTEM STACK” sub-menu, Up/Yes to continue, Left and Right to decrement or increment the stack no.

The state of the FAULT flag for the selected stack is displayed. Press Down/No to return to the stack no. display, Up/Yes to continue, Left and Right have no effect. The FAULT flag is set by the TEST routine, it is not possible to manually edit it.

The state of the ENABLE flag is displayed. Press Down/No to return to the FAULT flag display, Left or Right to toggle the flag, Up/Yes has no effect. The ENABLE flags are stored in battery backed RAM.

f) REMOTE

The µP will enter REMOTE mode if it receives an ESC character while displaying the main menu. In REMOTE, the unit accepts commands in simple ASCII characters and transmits its responses. There is no handshake, this mode is designed to work with a simple terminal or terminal emulator.

On entering REMOTE, the µP prints a “Kentech Instruments” banner, then waits for the user commands. The user can obtain a list of commands by typing HELP {cr}. The common commands are listed below for convenience:-

RUN {cr} to enable PBG5 stacks and trigger
STOP {cr} to disable all PBG5 stacks and trigger

TEST {cr} to run PBG5 self test routine
TESTRESULTS {cr} to list results from the self test routine
STATUS {cr} to give a listing of status information

n ENABLE {cr} to enable stack no. n
n DISABLE {cr} to disable stack no. n

n !AMPLITUDE {cr} to set the amplitude to n (in the range 60 to 100)
?AMPLITUDE {cr} returns the current amplitude setting

HELP+ {cr} to get help on less common commands
LOCAL {cr} to return to local mode ok

On returning to local mode, the “Kentech Instruments” banner is displayed once again on the LCD, quickly followed by the main menu.

f) Software Maintenance

Every effort has been made to minimise the number of errors in the software. Please report any problems in writing to Kentech instruments Ltd.

SPECIFICATIONS

General:

Number of outputs	One positive
Output amplitude	≥24kV into 50Ω
Amplitude jitter, shot to shot	<5%
Rise time	≤150ps (10 to 90%)
Pulse width	~2ns FWHM
Repetition rates	1000Hz
Power supply	230V ac at 50/60Hz, <200VA 110V ac selectable by internal link

Outputs:

Pulse output	Special connector
Pretrigger output	BNC ~10V into 50Ω, ~2ns risetime leads main output by selectable delay when delay active

Inputs:

Trigger input	BNC 5V, 50Ω, <5ns risetime
RS232	3 way Series 102 Fisher part no. SE102A052-130 9600 baud, 1 stop bit, no parity, 8 bit pin1 = receive pin3 = transmit pin2 = ground

Timing:

Trigger input to pulse out delay	~35ns (direct mode) ~52ns (delay mode)
Trigger input to pretrig out	~18ns (delay mode - delay set to minimum)
Jitter	<10ps RMS

Controls:

Mode	Sets one of the following modes: Single shot (delay active) 1 to 10Hz (delay active) 10 to 100Hz (delay active) 100Hz to 1kHz (delay active) *1kHz to 10kHz (delay active)**

* disabled

External trigger (delay active)

	External trigger (delay inactive)
Fine rate	Varies internal rate by a ratio of 10:1
Coarse delay	Varies internal delay in ~10ns steps
Fine delay	Varies internal delay continuously over ~15ns
Single shot button	Gives a single trigger in single shot mode
Power	Switches AC power in the pulser
Keypad	Up, Down, Left and Right keys

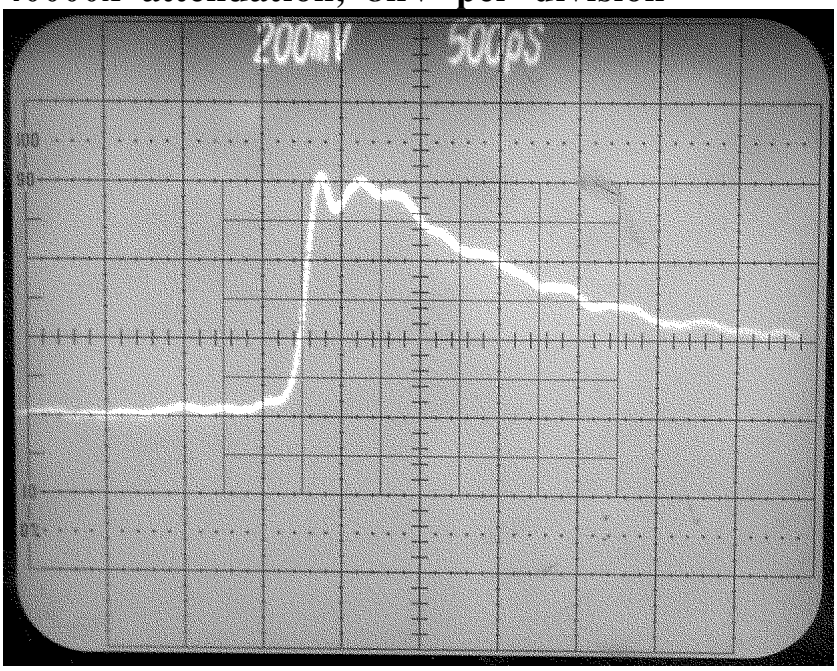
Indicators:

Power	Shows that AC power is applied and the unit is switched on
Triggered	Illuminates when the unit is triggered
LCD	One line 16 character display

Test data - SN J0012191

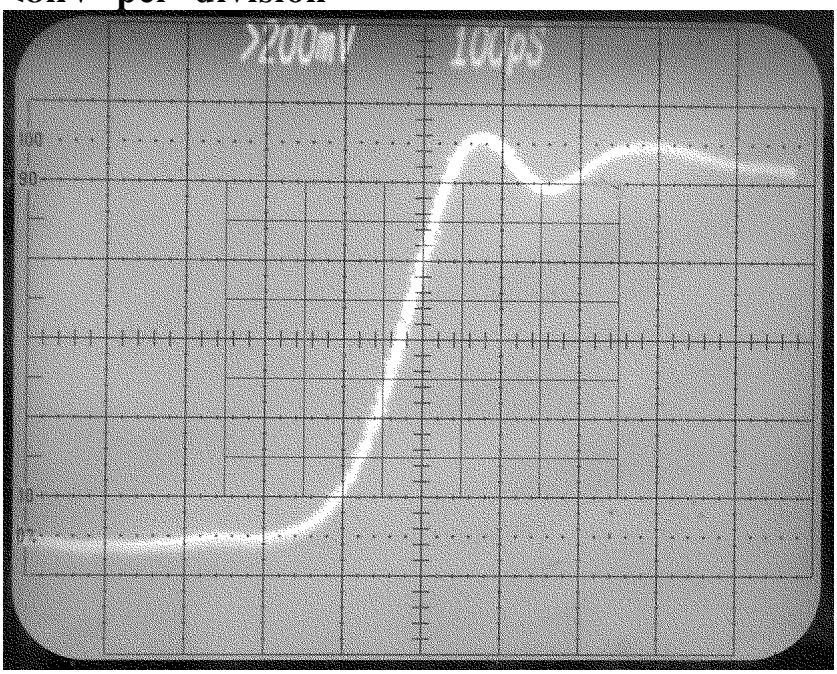
Test equipment:
Tek S4, 7S11, 7T11
Barth 142 20dB x 2, Radial 20dB SMA x 2, 2x suicide T x 2

40000x attenuation, 8kV per division



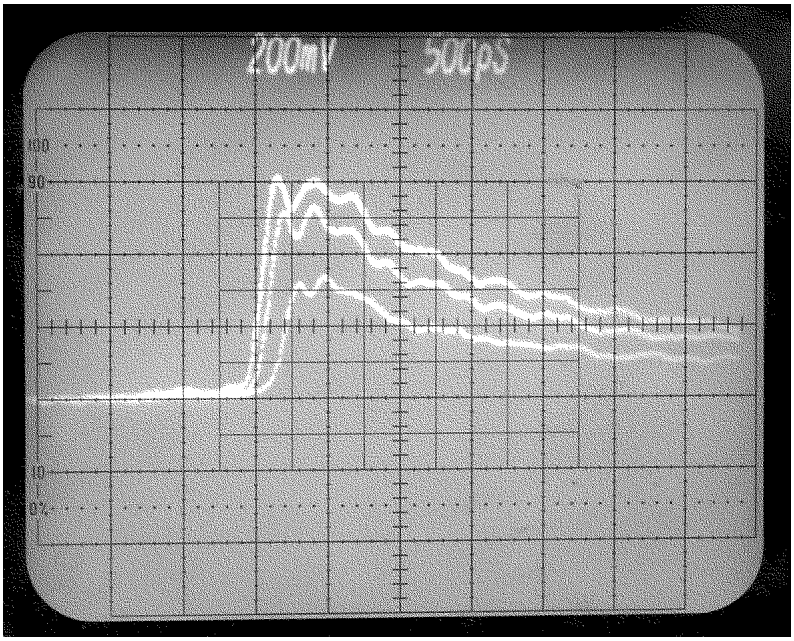
100% output

<8kV per division



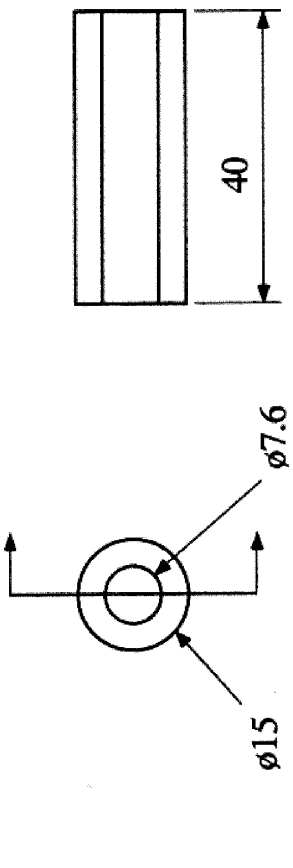
Showing risetime and jitter
T rise ~130psecs
Jitter <10ps rms

8kV per division

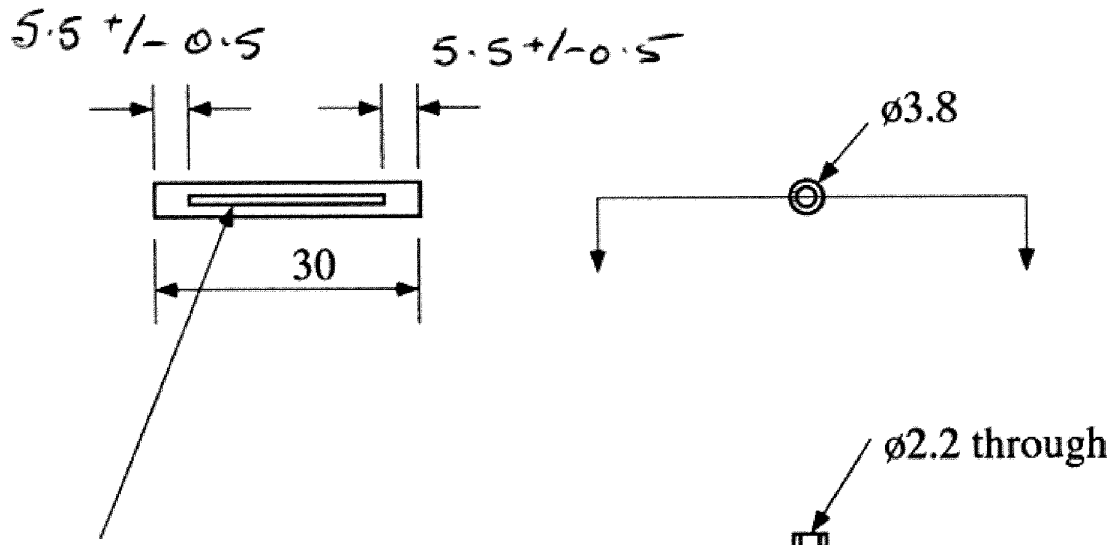


100%
80% and
60%
amplitude setting

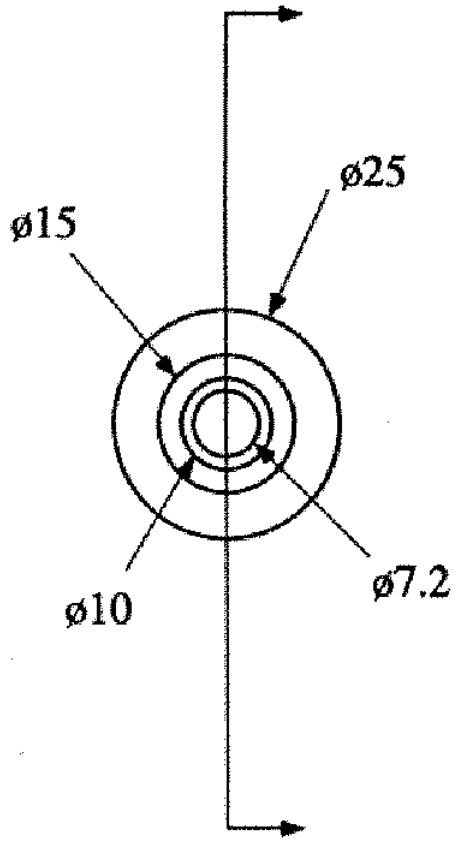
Output connector components (not to scale):

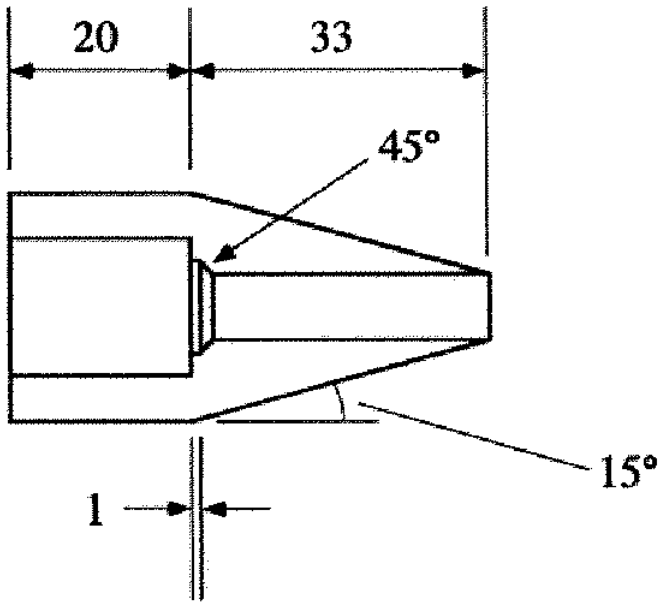


Job	PBG5 tapers
Item	Connector insulator sleeve
Material	PFTE
Dims	mm
Tolerance	0.2
Scale	1:1
Finish	Clean
	For missing dimensions assume symmetry
Date	22/2/01

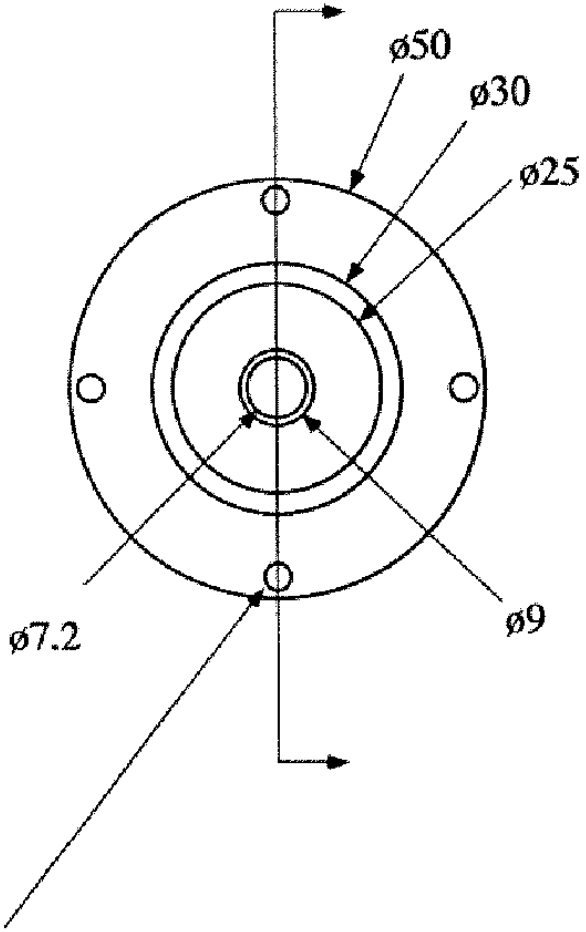


Job	PBG5 tapers
Item	Output connector spring contact
Material	Brass
Dims	mm
Tolerance	0.2
Scale	1:1
Finish	Clean
	For missing dimensions assume symmetry
Date	22/2/01

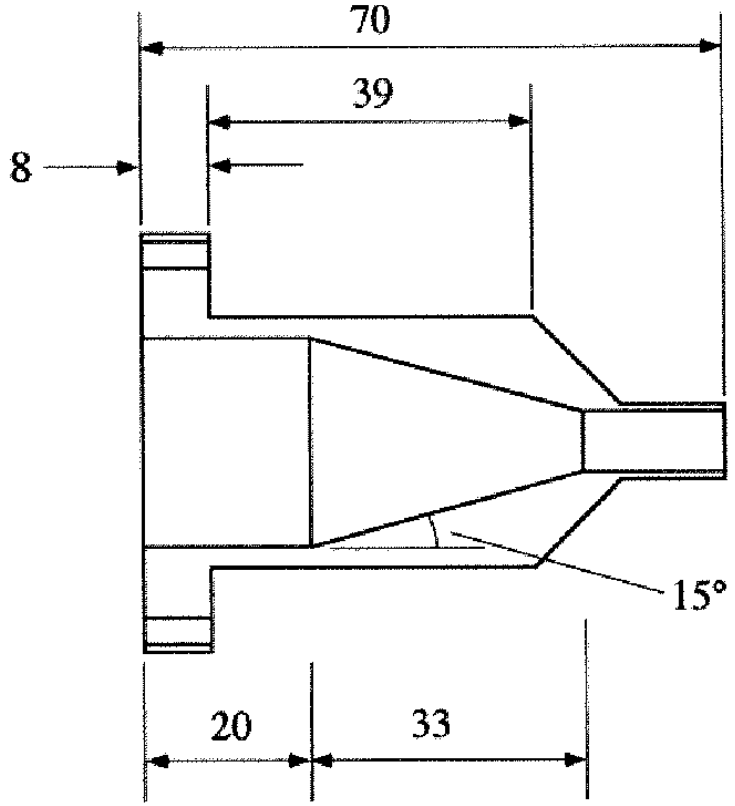




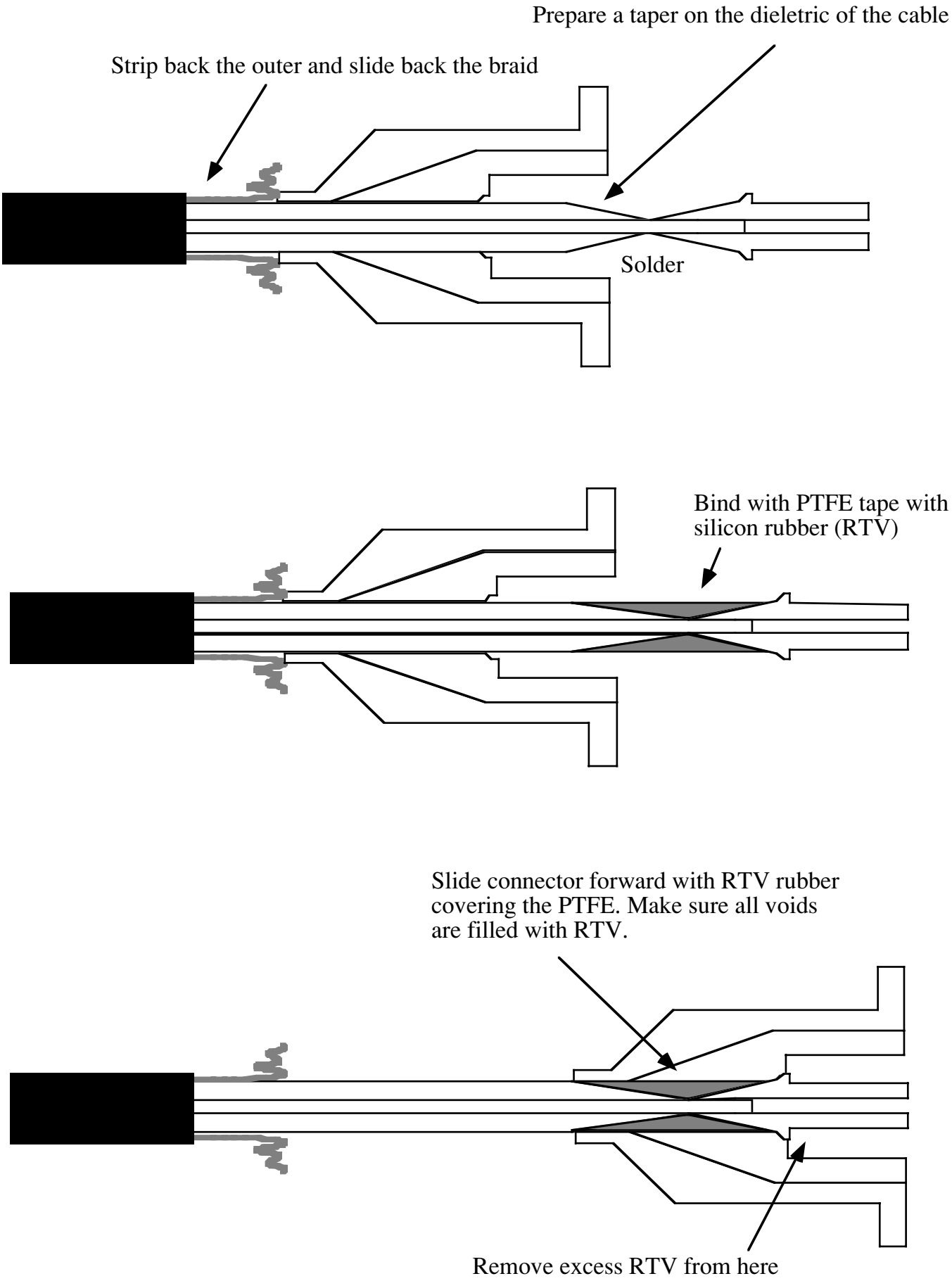
Job	PBG5
Item	Cable connector insulator
Material	PTFE
Dims	mm
Tolerance	0.2
Scale	1:1
Finish	Clean
	For missing dimensions assume symmetry
Date	22/2/01



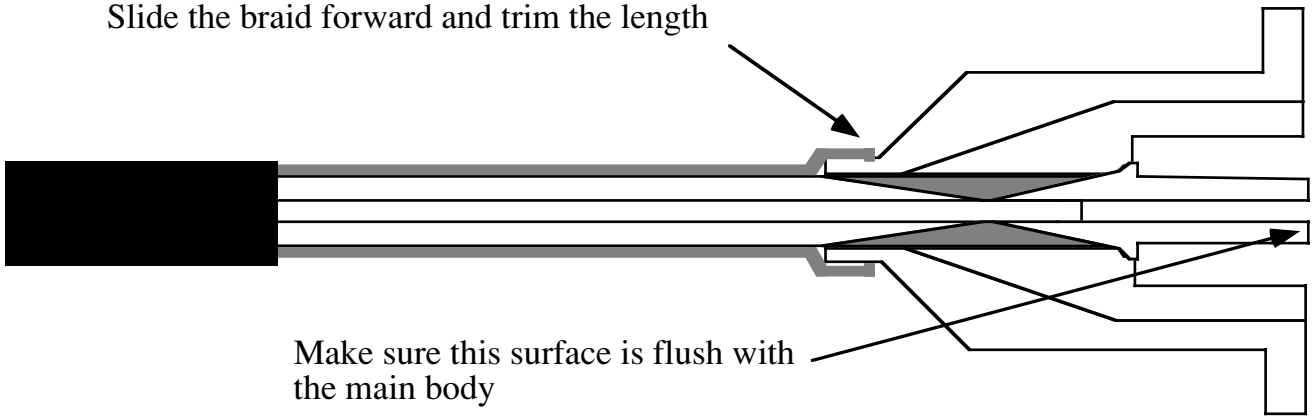
4 drill ø3.2 on 42pcd
equi.sp. as shown



Job	PBG5 tapers
Item	Cable connector body
Material	Brass
Dims	mm
Tolerance	0.2
Scale	1:1
Finish	Clean
	For missing dimensions assume symmetry
Date	22/2/01

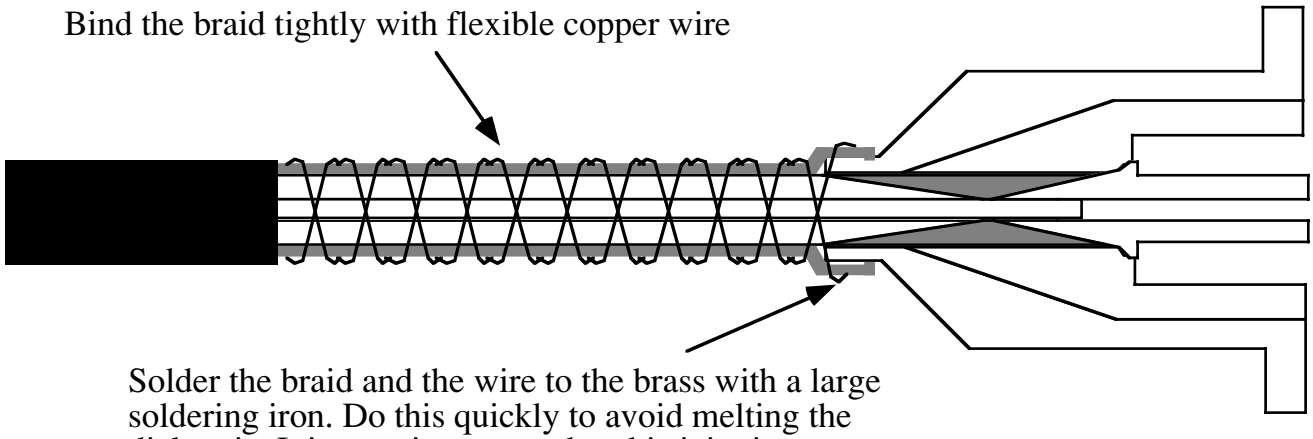

Prepare a taper on the dieletric of the cable
Strip back the outer and slide back the braid
Solder
Bind with PTFE tape with
silicon rubber (RTV)
Slide connector forward with RTV rubber
covering the PTFE. Make sure all voids
are filled with RTV.
Remove excess RTV from here

Slide the braid forward and trim the length

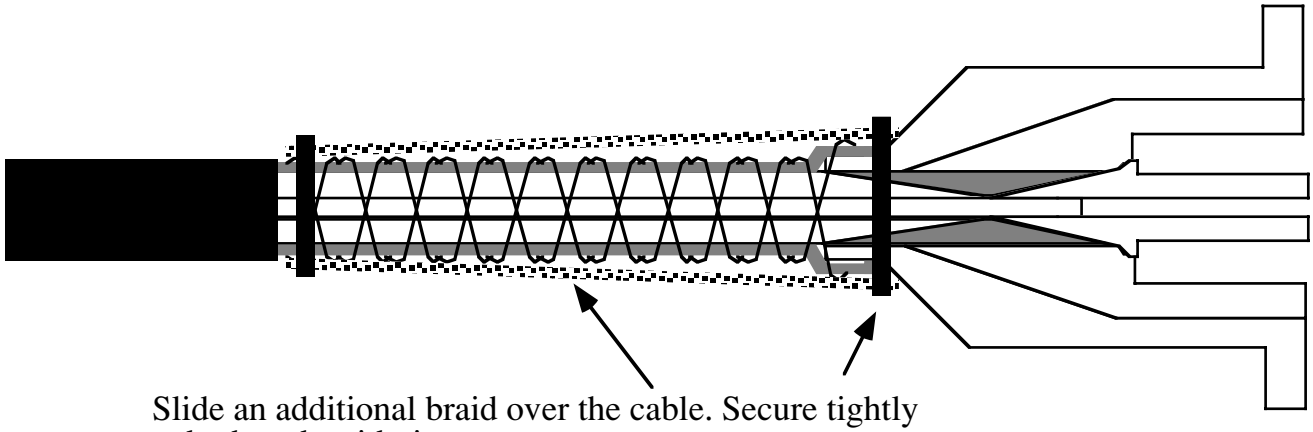


Make sure this surface is flush with the main body

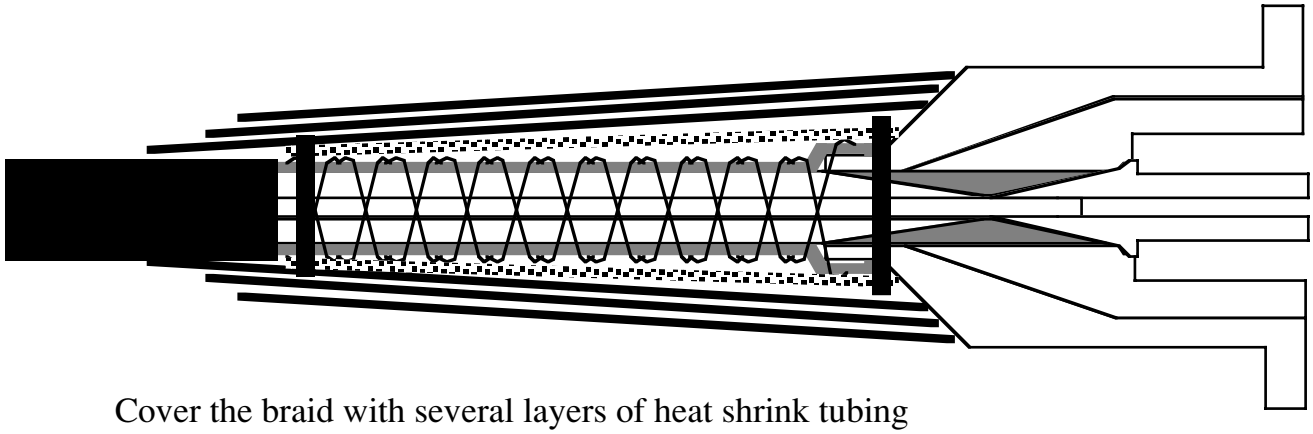
Bind the braid tightly with flexible copper wire



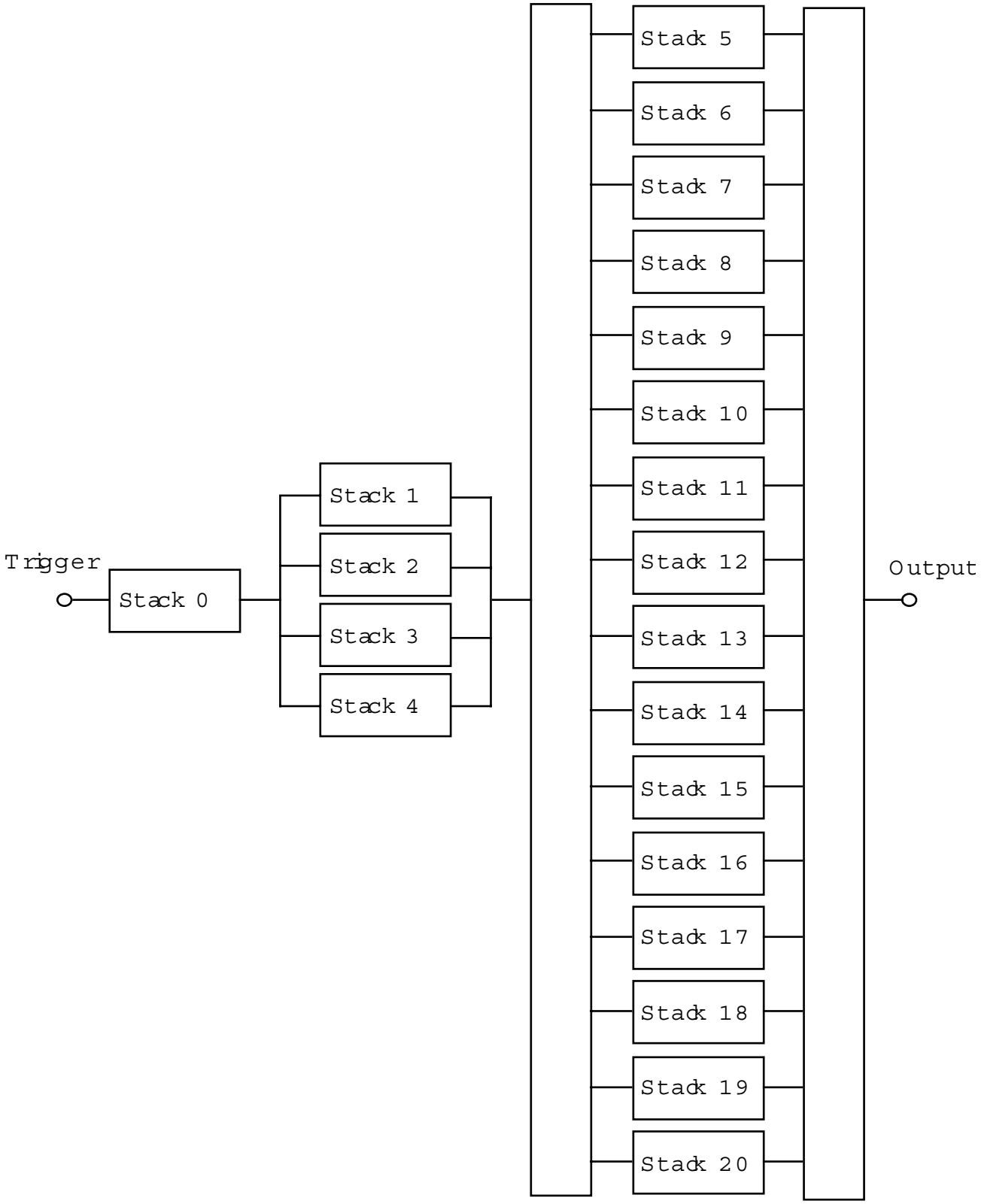
Solder the braid and the wire to the brass with a large soldering iron. Do this quickly to avoid melting the dielectric. It is very important that this joint is strong so the earth connection is secure.



Slide an additional braid over the cable. Secure tightly at both ends with tie wraps.



Cover the braid with several layers of heat shrink tubing



PBG5 Architecture