



emMesh2 – User Guide

Hardware Revision 2.2

Firmware Version 2.217

Document Version : A (05/01/2026)

Table of Contents

1. Revision History
2. Trademarks & Copyrights
3. Disclaimers
4. Introduction
5. Document Related Firmware and Hardware
6. Technical Specifications
 - 6.1 Form Factor
 - 6.2 General Specifications
 - 6.3 Interfaces
 - 6.4 Specifications
 - 6.5 Regulatory Conformity Summary
7. Technical Drawing
8. GPIOs
 - 8.1 16-Pin Connector
 - 8.2 8-Pin Connector
9. Design Notes
 - 9.1 Power Supply Design
 - 9.2 Board Layout
 - 9.3 Antenna Performance
10. Serial Communication Protocol
 - 10.1 Introduction
 - 10.2 Generic Message Structure
 - 10.3 Communication Protocol

10.4	Encryption
10.5	Message Types
11.	Payload Structure
12.	Regulatory Information
13.	Warranty

1. Revision History

Revision	Date	Description
A	Jan 2026	Creation of document

2. Trademarks & Copyrights

Penteract and emMesh logos are protected properties of **Les Consultants Penteract Inc.** or **Penteract Consulting Inc.**

Usage of these logos is strictly prohibited without written consent.

© 2018 Penteract Consulting Inc. – All rights reserved.

3. Disclaimers

Information in this document is subject to change without notice and does not represent a commitment on the part of Penteract Consulting Inc.

This document is provided “*as is*”, without warranty of any kind, expressed or implied.

4. Introduction

The *em* series are long-range 915 MHz radios (up to 16 km) using mesh topology to provide connectivity in areas without traditional networks.

They are optimized for:

- ultra-low power consumption,
- long-range communication,
- large sensor networks,
- near-real-time monitoring.

The emMesh uses the **Microchip MRF89A** chipset, amplified to **26 dBm**, with sensitivity down to **–103 dBm**.

5. Document Related Firmware and Hardware

This document refers to:

- **Hardware revision:** 2.2
 - **Firmware version:** 2.217
-

6. Technical Specifications

6.1 Form Factor



6.2 General Specifications

Parameter	Value
Frequencies	Americas: 902–928 MHz
Network size	Up to 64,006 units
Bandwidth	19,200 bps (P2P)
FHSS	15.6 ms, 50 channels
Internal memory	4 Mbit Flash
Antenna connector	U.FL (50 Ω)

6.3 Interfaces

Interface	Description
UART	1 communication UART, 1 debug UART
I/O	10 programmable I/O pins
SPI	Up to 1 Mbps
USART	I ² C
ADC	2× 12-bit analog inputs (0–2 V)
PWM	5 PWM outputs

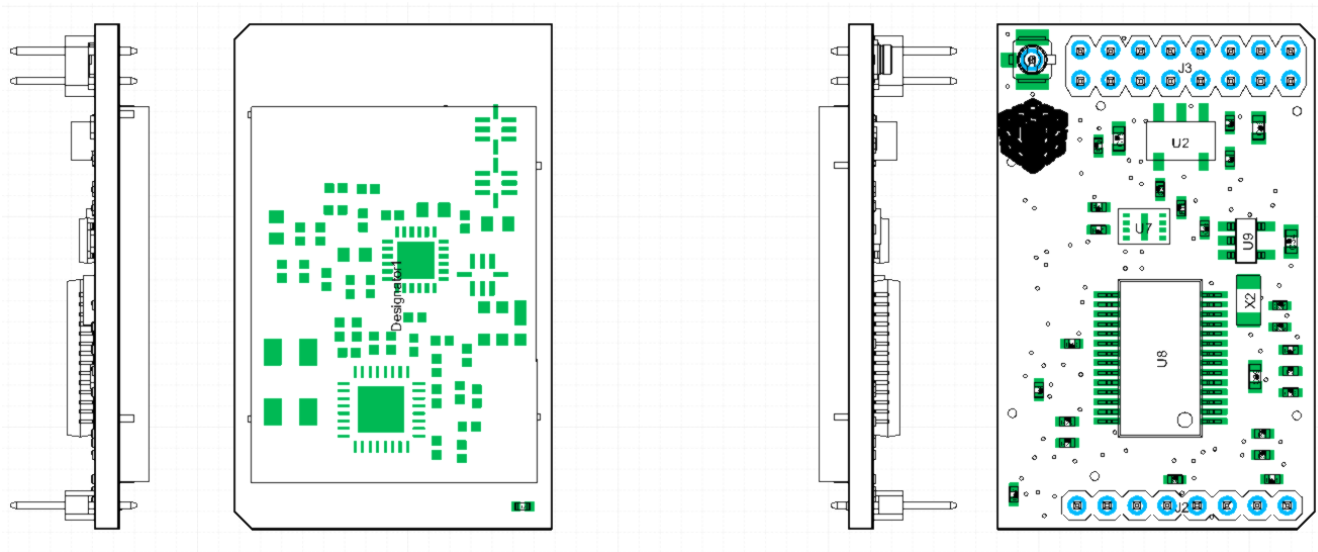
6.4 Specifications

Parameter	Value
Dimensions	34 × 21 × 10 mm
Operating temperature	–20 °C to +70 °C
Storage temperature	–40 °C to +85 °C
Operating voltage	3.3 V to 5.5 V
Typical consumption	5 mAh
Antenna	Wire or U.FL port
Transmit power	25 dBm
Sensitivity	–103 dBm

6.5 Regulatory Conformity Summary

Region	Certification
USA (FCC Part 15.247)	FCC 47 CFR Part 15 Subpart C, §15.247
Canada (ISED)	RSS-247, Issue 4, July 2024, Section 6

7. Technical Drawing



8. GPIOs

8.1 16-Pin Connector

Pin	Name	Type	Description
1	Ground	P	Ground reference
2	PPR	O	Power-Present (open-drain)
3	Ground	P	Ground reference
4	TX2	I/O	I/O or UART TX
5	BAT+	P	3.3–5.5 V input
6	RX2	I/O	I/O or UART RX
7	TX	I/O	I/O, UART TX, or I ² C SDA
8	AN1	I/O	Analog input
9	AN2	I/O	Analog input
10	RX	I/O	I/O, UART RX, or I ² C SCL
11	NC		
12	PWM2	I/O	PWM output
13	NC		
14	NC		
15	3.3V	P	3.3 V output (200 mA max)
16	NC		

8.2 8-Pin Connector

Pin	Name	Type	Description
1	nMCLR	I	Reset (active low)
2	3.3V	P	3.3 V output
3	GND	P	Ground
4	PGD	I/O	Programming data
5	PGC	I/O	Programming clock
6	GND	P	Ground
7	PWM1	O	Status LED
8	NC		

9. Design Notes

9.1 Power Supply Design

- Single external supply required
 - Ripple < 100 mV
 - Peak current capability: 250 mA
 - Add 100 μ F capacitor at input
-

9.2 Board Layout

- No special constraints except antenna area
 - Follow standard PCB practices
-

9.3 Antenna Performance

Recommendations :

- Antenna vertical
 - Keep away from metal
 - Use external antenna if enclosure is metallic
 - No ground plane under antenna
 - Place module at PCB edge
-

10 Serial Communication Protocol

10.1 Introduction

The following document refers to Penteract emToo Protocol for Generic implementation.

emToo Protocol works as a global multi-layer, multi-protocol mesh type networking. Allowing multiples protocol such as WiFi, ISM, IP or Bluetooth to interact with each other transparently and be use as a unique transport layer.

The protocol is defined by two mode: Simplified protocol and Advanced Protocol. Description of both mode could be found later in that document.

Choosing the protocol that is more suitable for your needs can lead to simplistic to more complex implantation requirements.

10.2 Generic message structure

Both mode, simplified or advanced are using the same base structure. Both are meant to be efficient on any type of transport protocol and secured in both possible encryption and integrity of datas.

Every message sent thru emToo protocol must be packet for the Transport layer structure.

Said transport layer is what is creating the capacity to travel on every type of protocols.

Transport layers such as IP, Serial or Bluetooth are completely transparent and rely on a Mesh reality which held, depending on protocols on a system of relay which allowed a packet to switch from one type of transport to the other without the system needing to know it.

This is coming with some limitation like payload size with is maintained fairly small as it allows smaller capacity type of transport such as emMesh and BLE to be able to participate as said mesh reality.

Although said payload could be increased if protocol is only used in IP, knowing which device will be used as relay is fairly important to allows said behaviour and we do not recommend it.

10.3 Communication protocol

A message sent must begin with 0x24 0x24 and end with 0x0D 0x0A. In addition, it must contain a size, 8 bits checksum, the message type used and the type of encryption used.

sync	sync	length	msg type + encryption	Payload type	Data	Data	Data	Data
0x24	0x24	0x0F	0x00	0x02	0x41	0x41	0x41	0x41

Data	Data	Data	Data	Data	checksum	Byte termination	Byte termination
0x48	0x45	0x4C	0x4C	0x4F	0x40	0x0D	0x0A

Table 1: example of a simplified type of message

In the example on Table 1, byte[1 & 2] are the sync characters which are always, whether in simplified or

advanced mode, \$\$.

byte[3] Length:

This byte is a computation of the size of the payload the msgType and itself.

byte[4] Msg Type & Encryptio:

This byte is created by mixing the binary values [MSB 1bits Advanced=1 Simplified=0][LSB 7 bits Encryption Type]

Exemple:

Encryption_Type = 0x01;

Msg_Type = 0x01;

byte[4] = Msg_Type<<7 + Encryption_Type;

byte[4] = 0x81

Please see MsgType and Encryption type section for more infos.

byte[n-3] Checksum:

The checksum is calculated over payload using and 8 bits exclusive or (XOR) sequence. It is done prior to encryption and include payload type.

byte[n-2] & byte [n-1] Ender:

Each message must be terminated by \r\n (0x0D, 0x0A). This allows both packet end but also correlation of length on which if both values are not equals, message is discarded.

10.4

Encryption (6 bits)

Encryption Type <6: 0>	Value	Description
No	0x00	Raw message, no encryption
Polymorphism	0x01	Simple light cypher algorithm based on polymorphism of paraphrase.
Rijndael [CBC]	0x02	Rijndael implentation cypher. (Not on emMesh)
AES 256bits	0x03	AES-256 standard (Not on emMesh)
RSA 2048	0x04	To come
256 bits ECC	0x05	To come
User Defined	0x06 to 0x7F	Supported only by certain devices

Message Type (1 bit)

Message Type <7>	Value	Description
Simplified	0x00	Set following message as being in simplified mode
Advanced	0x01	Set following message as being in advanced mode

Simplified Mode

In simplified mode, the associated device using is acting a a slave accessories. Using that protocol ease the integration by simply allowing

Message types

The difference between the simplified and advanced type of message is the addition of two headers and types of payload possible In the message forward must provide the header of "peer to peer" and "Mesh". The simplified type of messages can only use the types of payload dataWithoutAck and dataWithAck

Payload: Simplified Message type

BYTE	Value	Description
0	0x24	Bytetiming
1	0x24	synchronization Byte
2	0-n	message size
3	0x00 0x00-0x7F	Message Type < 7> encryption Type <6: 0>
4 n - 4		Payload []
n - 3		Checksum
n - 2	0x0D	ender byte 1
n- 1	0x0A	ender byte 2

Table 2: Structure of a simplified message type

Message Type advanced

BYTE	Value	Description
0	0x24	Bytetiming
1	0x24	synchronization Byte
2	0-n	message size
3	0x01 0x00-0x7F	Message Type <7> encryption Type <6: 0>
4-7		destination P2P
8-11		P2P origin
12	0x00-0xFF	Message Type Mesh
13	0x00-0xFF	Message ID Mesh
14	0x00-0xFF	message reception confirmation ID Mesh
15-18		Mesh origin
19-22		Mesh Destination
23	0x00-0xFF	level compared to sending the message
24 to n - 4		Payload []
n - 3		ChkSum
n - 2	0x0D	Ender byte 1
n - 1	0x0A	Ender byte 2

Table 3: Structure of an advanced type of message

Encryption Types

Encryption Type <6: 0>	Value	Description
No	0x00	
Polymorphism	0x01	
RijndaelManaged[CBC]	0x02	
RSA 2048 bits	0x03	

11 Payload

Payload has a variable maximum size of 38 bytes. The first byte must be the type of payload of 5 bit and an encryption index of 3 bit. The byte 0 is therefore never encrypted because it contains the information necessary for decryption.

Payload [0] PayloadType <4: 0>

type payload <4: 0>	value	Description
TypeID	0x00	Return of identification information
Refresh	0x01	Backinformation about theModule
DataWithoutAck	0x02	Back / Send data without receiving confirmation
DataWithAck	0x03	Back / Send data with confirmation of receipt
FileTransfer	0x04	Sends data with afile transfer protocol
undefined	0x05 to 0x1B	
event	0x1C	event Type
return	0x1D	type return
Get	0x1E	type get
set	0x1F	Type set

Table 5: List of types of payload

payload [0] PayloadType <7: 5>

The encryption index is sent on 3 bit at index 0 of the payload.

See the section Payload encryption.

TypeID

Returns module identification information within a "CSV"

Structure of the typeID varies according to the device name.

See the documentation on the module concerned for details.

Example of "CSV" structure: "device name, firmware version, hardware version Version EEPROM memory"

Refresh

Return the module information. The type refresh must provide at least 3 information which are: the level

relative to the origin of the request, the relay used to communicate with the origin and the ID of the group. The rest of the payload is variable depending on the module, see the documentation on the module concerned for details.

Payload []	Value	Description
0	0x01	Typepayload
1	0x00 - 0x1E (invalid: 0x1F)	level compared to the original
2 to 5		Relay
6	0x00 - 0xFF (default: 0xFF)	Group ID
7 to...		Module Based.

Table 6: Structure of the refresh type payload

DataWithoutAck

Back / Sends data without reception confirmation.

DataWithAck

Back / Send data with confirmation of receipt. Upon receipt of a message type dataWithAck a message subtype ackData will be sent to the origin.

FileTransfer

Sends data with a file transfer protocol.

Event

Type of event, see subtypes events for details.

Return

Return type, see subtypes back for details.

Get

Type of application, see the application subtypes for details.

Set

Type of modification, see subtypes changes for details.

Payload [1]: sub-type <7: 0>

Return Type	Value	Description
AckData	0x03	Receipt Confirmation
RoutingTableInfo	0x20	ID and level of known modules
TableLvl1	0x21	ID of this module in the level table 1
DebugInfos	0x22	
Settings	0x23	Module Settings
RSSI	0x24	signal strength between two modules
MasterID	0x25	master ID
NackInfos	0x2B	Confirmation not received
DecryptionError	0x2C	Error decryption
WrongParameter	0x2D	Invalid Parameter

AckData 0x03

Message receipt Confirmation. The message ID of the header "Mesh" is returned in the payload to indicate which message is confirmed.

RoutingTableInfo 0x20

List ID and level of known modules. For each index 3 requested destination of their associated relay and level will be sent. The possible index values are from 0 to size max / 3, round up if max size / 3 does not give a whole. If the 3 destinations are received 0xFFFFFFFF, it means that the module has not other destinations in its routingTable from this index.

0x1D	0x20	Index	Max	Dest [4]	relay [4]	Level
Dest [4]	relay [4]	Level	Dest [4]	relay [4]	Level	

TableLvl1 0x21

List ID modules that are present in the level of table 1. For asked each index 8 ID will be send. The possible index values are from 0 to size max / 8, rounding up if size max / 8 does not give a whole.

0x1D	0x21	Index	Max	8 x ID [4]
------	------	-------	-----	------------

DebugInfos 0x22

Information on the module. See the documentation on the module concerned for details.

Settings 0x23

Returns module parameters. See the documentation on the module concerned for details.

Rssi 0x24

Returns signal strength. See the documentation on the module concerned for details.

MasterID 0x25

Returns the master ID.

NackInfos 0x2B

Confirmation of non-receipt of the message. The message ID of the header "Mesh" is returned in the payload to indicate which message failed.

DecryptionError 0x2C

Decryption error detected. The message ID of the header "Mesh" is returned in the payload to indicate on what message the error occurred.

WrongParameter 0x2D

Parameter error detected. The message ID of the header "Mesh" is returned in the payload to indicate on what message the error occurred.

Payload [1]: subType <7: 0>

Application Type	value	Description
TypeID	0x00	Request of identifications information
Refresh	0x01	Request information from aModule
RoutingTableInfo	0x20	Request ID and the modules known
TableLvl1	0x21	Request the IDs of the modules present in the level 1 table
DebugInfos	0x22	
settings	0x23	module parameters Application
RSSI	0x24	Request signal strength between two modules
MasterID	0x25	request of the master ID

TypeID 0x00

Request of identifications of the information module. See the documentation on the module concerned for details.

Refresh 0x01

Application of module information. For each index requested 8 ID will be send. The possible index values

are from 0 to $\text{size max} / 8$, rounding up if $\text{size max} / 8$ does not give a whole.

RoutingTableInfo 0x20

Application part of the list of known modules. For each index 3 requested destination of their associated

relay and level will be sent. The possible index values are from 0 to $\text{size max} / 3$, round up if $\text{max size} / 3$

does not give a whole.

TableLvl1 0x21

Application part of the list of modules that are present in the table level 1. See the documentation on the

module concerned for details.

DebugInfos 0x22

Information on the module. See the documentation on the module concerned for details.

Settings 0x23

Request module parameters. See the documentation on the module concerned for details.

Rssi 0x24

Returns signal strength. See the documentation on the module concerned for details.

MasterID 0x25

Request the master ID.

Type of change	value	Description
Settings	0x23	module parameters Modifications
MasterID	0x25	Changing the master ID
ForceRelay	0x26	Changing IDforced relay
Password	0x26	Changing the password
ResetMcu	0x28	RestartModule
CloseDevice	0x29	Module Closing

0x23Settings

Changing the module parameters. See the documentation on the module concerned for details

MasterID 0x25

Changing the master ID. Put into the desired payload ID.

ForceRelay 0x26

Changing the ID of forced relay. Put into the desired payload ID.

Password 0x26

Changing the password. Put in the payload the desired password.

ResetMcu 0x28

Reset the microcontroller.

CloseDevice 0x29

Close the module. Provide the unit of time (see Table 11) on a byte tracking time of 2 bytes (MSB

followed by the LSB). Example: 4096 minutes = 0x02 0x10 0x00

Time unit	value
Milliseconds	0x00
Seconds	0x01
minutes	0x02
Hours	0x03

Table 11

12 Regulatory Informations

FCC Compliance Disclaimer (Class B)

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Please note that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC RF Exposure Statement (MPE)

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, this equipment should be installed and operated with minimum distance 20 cm (7.9 inches) between the antenna and your body during normal operation. Users must follow the specific operating instructions for satisfying RF exposure compliance.

ISED Non-interference Disclaimer

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference.
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

This device complies with the Canadian ICES-003 Class B specifications. CAN ICES-003(B) / NMB-003(B).

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempt de licence. L'exploitation est autorisée aux deux conditions suivantes :

- (1) L'appareil ne doit pas produire de brouillage;
- (2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

ISED RF Exposure Statement (MPE)

This equipment complies with ISED RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm (7.9 inches) between the radiator and any part of your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Cet équipement est conforme aux limites d'exposition aux radiations ISED CNR-102 établies pour un environnement non contrôlé. Une distance de séparation d'au moins 20 cm doivent être maintenue entre l'antenne de cet appareil et toutes les personnes. Lanceurs ou ne peuvent pas coexister cette antenne ou capteurs avec d'autres.

ISED Detachable Antenna Statement

This radio transmitter IC: 24776-EMMESH2 has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio IC: 24776-EMMESH2 a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

Under Innovation, Science and Economic Development regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by ISED. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Conformément à la réglementation d'Innovation, Sciences et Développement économique Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Innovation, Sciences et Développement économique Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Approved Antenna Types:
half-wave dipole antenna, 3 dBi gain

Module Integration Instructions (FCC/ISED)

This radio module is authorized for use in other devices only by OEM integrators under the following conditions.

1. Host Labeling Requirements

The host product into which this module is installed must be labeled with the following statement in a visible location on the exterior of the final product:

“Contains FCC ID: 2ASI4EMMESH2, IC: 24776-EMMESH2”

If the host device is too small to display this statement, it may be placed in the user manual and/or on the packaging in accordance with FCC and ISED labeling requirements.

2. Compliance of the Host Product (Part 15B and ICES-003)

The radio module is approved under ISED and FCC rules as a modular transmitter. However, the final host product must still be evaluated for compliance with **FCC Part 15, Subpart B** and **ISED ICES-003**(unintentional radiators).

The integrator is responsible for performing any required Part 15B/ICES-003 testing of the final host device, such as verification or Declaration of Conformity, depending on the device classification.

3. Installation Restrictions

This module may only be installed in host devices by the OEM integrator. End users are not permitted to install or remove this module.

The integrator must ensure that the module is installed in accordance with the manufacturer's instructions and that no unauthorized modifications are made to the module or its antenna system.

4. Co-location and Antenna Use

The module must not be co-located or operating simultaneously with any other antenna or transmitter except in accordance with FCC/ISED multi-transmitter procedures and only if additional authorization is obtained.

Only antennas approved for use with this module may be used. Any antenna changes require re-evaluation and approval.

13 - For product support, warranty information, or replacement parts, please contact:

Les Consultants Penteract Inc
2376 rue Galvani, bureau 110
Quebec, Quebec, G1N 4G4, Canada
Phone: 1-418-800-1360
Email: infos@penteract.ca
Website: www.penteract.ca